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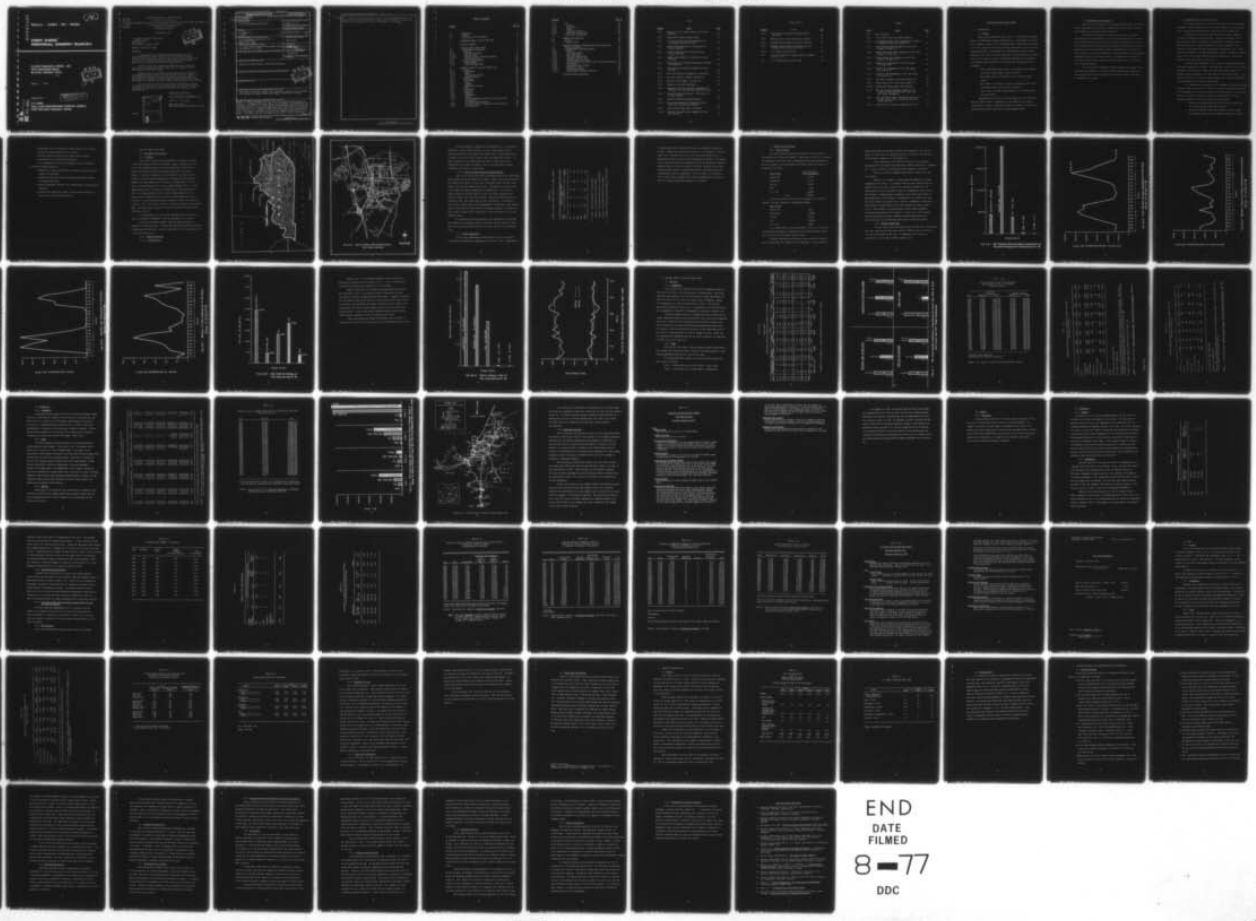

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Report · FESA - RT - 2026

FORT KNOX
REGIONAL ENERGY SURVEY

H.D. NOTTINGHAM & ASSOC., INC.
7900 WESTPARK DRIVE
McLEAN, VIRGINIA 22101

January · 1977

prepared for

U.S. ARMY
FACILITIES ENGINEERING SUPPORT AGENCY
FORT BELVOIR, VIRGINIA 22060

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January 31, 1977

U. S. Army Facilities Engineering
Support Agency
Building 374
Fort Belvoir, Virginia 22060

Subject: DAAK 70-76-C-0275

Gentlemen:

In compliance with our agreement for professional services, we have prepared this report entitled "Fort Knox Regional Energy Survey." Seventy-five (75) copies of this document are being delivered on this date. Recommendations made in this report are based upon analysis of factual data and good engineering practices.

A draft of this final report was submitted to your office for your review and comments; we have incorporated our response to these observations in this final report.

We appreciate the opportunity to have worked on this interesting and challenging energy study. The help and cooperation of a number of individuals within and outside the Government during the conduct of this study are recognized. Special gratitude must be expressed for the assistance of Dr. Harold Hollis, Mr. Casimir Kukielka and Mr. Duane Nelson.

We trust that you will find this document satisfactory. We will be pleased to meet with you at your convenience to discuss data presented and answer any questions you may have concerning the contents of this investigation.

Respectfully submitted,

H. D. NOTTINGHAM & ASSOCIATES, INC.

Tara Singh

Tara Singh, Ph.D.
Registered Professional Engineer #7271

TS/jpw

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) UNCLASSIFIED

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: USAFESA-RT-2026
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): Fort Knox Regional Energy Survey.

5. TYPE OF REPORT & PERIOD COVERED: Final rept.

6. PERFORMING ORG. REPORT NUMBER: Fort Knox Energy Study

7. AUTHOR(s): R. Beaudry, Jr.
T. Singh

8. CONTRACT OR GRANT NUMBER(s): DAAK 70-76-C-0275

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
H. D. Nottingham & Associates, Inc.
7900 Westpark Drive
McLean, Va. 22101

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: FESA-RT-2026

11. CONTROLLING OFFICE NAME AND ADDRESS:
U. S. Army Facilities Engineering Support Agency
Fort Belvoir, Va. 22060

12. REPORT DATE: January 1977

13. NUMBER OF PAGES: 92

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release, Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Army, Coal, Electricity, Energy, Fixed Facilities, Fuels, Fuel Oil, Heating and Cooling, Heat Pumps, Natural Gas, Propane, Solid Wastes, Storage

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Impact of energy consumption at Fort Knox on the regional energy supply was assessed. Consumption of natural gas at the installation was significant with the post using 1.25% of the total natural gas consumption within the State of Kentucky and 3.45% of the total natural gas sales of its supplier (Louisville Gas & Electric Co.). Supply of other sources of energy in the region such as fuel oil, propane, coal and electricity is not impacted significantly by the Post. Fort Knox's bill for all energy sources for FY 76 was $5.1 million. → next page (over)

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cont

To meet future energy demands of the Post, several recommendations have been made in the form of an energy plan; however, further studies are required to establish the feasibility of some of the alternatives outlined.

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1. INTRODUCTION

1.1 Purpose

Under contract DAAK70-76-C-0275, the U. S. Army Mobility Equipment Research and Development Command commissioned H. D. Nottingham & Associates, Inc. to conduct a survey of the non-transportation energy resources utilized at Ft. Knox, Kentucky and relate this energy expenditure to its availability and projected cost. By developing such relationships, pertinent energy decisions at Ft. Knox can be made rationally, and opportunities for cooperation with the region in easing a common energy problem can be established. To accomplish these objectives, the following four basic questions were considered:

- What relationships exist between the installation and regional (statewide) energy supply, usage, and costs?
- What impact does the installation have on the surrounding region?
- What impact or contribution could the installation make on the surrounding region and the State of Kentucky?
- What changes in factors would contribute to increased economy and conservation?

Opportunities in the area of energy supply have been identified where Ft. Knox can make a contribution to the communities and region surrounding it. However, additional studies are required to establish the economic and technical feasibility of these suggested ideas.

1.2 Methodology of Investigation

Data for this investigation was gathered through personal interviews, written communication and telephone conversations with facilities engineers, energy suppliers and regional energy authorities.

The majority of information and data pertaining to the physical and climatological characteristics of Fort Knox were provided by the Environmental and Energy Conservation Branch of Facilities Engineering at Fort Knox. Data concerning future construction was provided by the Department of Nuclear Engineering of the Massachusetts Institute of Technology and the Fort Knox Master Planner. The Kentucky Department of Energy provided the data regarding consumption of the various energy sources. The information concerning the electrical and gas utility serving Ft. Knox was provided by the Louisville Gas and Electric Company.

Once the survey of installation energy suppliers and regional energy authorities was completed, information gathered was carefully scrutinized and analyzed and the data was organized in the form of charts and graphs to be included in the report.

2. RECOMMENDED ENERGY PLAN FOR FORT KNOX

The basic objectives of an overall energy plan for Fort Knox should be focused on energy conservation as a short term objective and on conversion of oil- and gas-fired heating plants to coal-fired for the longer term.

The majority of the natural gas, oil, and coal energy consumed at Fort Knox is utilized for comfort heating. Most of the buildings at Fort Knox are not insulated in accordance with Department of Defense criteria for new construction. Dramatic reductions in energy consumption can be realized by conservation methods (installation of insulation, etc.). Since conservation methods can be implemented quickly and with a minimum of funding impact, they offer the most promising avenue of approach for a short term solution to the energy problem at Fort Knox.

The natural gas consumption at Fort Knox has a significant impact on the energy resources of the region. Fort Knox uses 1.25% of the total natural gas supply of the State of Kentucky and 3.45% of the total supply of the regional natural gas supplier, the Louisville Gas and Electric Company. Conversion by Fort Knox to coal as a primary energy source will have significant long term effects on the regional energy supply.

H. D. Nottingham and Associates, Inc. recommends the following priority listing of actions to achieve the short term and long term goals listed above. It is recognized that the order of priority of these actions may be revised by the post as technical feasibility and cost analysis studies are made, as funding availability varies and as master planning develops:

a. Formulate an emergency priority plan for energy conservation for the post during extreme fuel shortages.

b. Initiate feasibility studies for automatic control systems for building heating and air conditioning systems at the post.

c. Implement energy conservation measures in existing buildings at the post.

d. Prepare feasibility studies for on-site generation of electrical power utilizing waste heat for building comfort heating and cooling systems.

e. Initiate feasibility and cost studies for the conversion of oil-fired and gas-fired heating plants to coal firing.

f. Consider interconnections for existing heating plants.

g. Prepare feasibility studies for central plant heat pump systems utilizing well water or river water.

h. Consider on-site storage of natural gas to minimize demand charges.

i. Initiate feasibility studies for solid waste incineration with heat recovery.

j. Secure professional assistance for renegotiation of utility supply contracts.

k. Promote close cooperation between the post energy officers and regional and national energy agencies.

3. EXECUTIVE SUMMARY

The impact of the energy consumption at Fort Knox on the energy supply of the surrounding region and of the State of Kentucky has been assessed. Additionally, consumption of electricity and natural gas at Fort Knox has been compared to the total sales of the utility company providing these energy sources.

The post has a significant impact on the regional supply of natural gas. The post has no significant impact on the regional supply of fuel oil, propane, coal, or electricity. The following figures summarize the energy consumption of the post in FY 76 expressed as a percentage of the total energy consumption within the State of Kentucky:

Natural Gas	1.25%
Fuel Oil	0.7%
Propane	0.055%
Coal	0.0039%
Electricity	0.00025%

Fort Knox energy consumption of electricity and natural gas for FY 76 expressed as a percentage of sales of its supplier (Louisville Gas and Electric Company) is 1.9% and 3.45% respectively.

Total annual cost to the post for energy sources in FY 1976 was $5.1 million. Projected costs for this same amount of energy in FY 1985 are approximately $17 million.

It is recommended that Fort Knox undertake feasibility studies for the following energy conservation measures:

- On-site generation of electric power with waste heat reclamation.
- Central heat pump systems with water heat sink.
- Automatic control systems for building heating and air conditioning systems.

- Conversion of oil- and gas-fired heating plants to coal firing.
- Solid waste incineration with heat recovery.
- On-site storage of natural gas to reduce demand charges.
- Interconnection of existing heating plants.

It is recommended that Fort Knox accomplish as soon as possible the following energy objectives:

- Formulate an energy priority plan for energy conservation during extreme fuel shortages.
- Implement energy conservation measures and insulation upgrades in existing facilities.
- Secure professional assistance for renegotiation of utility supply contracts.
- Promote close cooperation between the post energy officers and regional and national energy agencies.

4. FACILITY ENERGY USAGE SURVEY

4.1 Description of Facilities

4.1.1 Location

Fort Knox is located 25 miles southwest of Louisville, Kentucky, at 37° 54'N latitude and 85° 58'W longitude. (Refer to Figures 4.1.1 and 4.1.2) The northwest boundary of the reservation lies along the Ohio River, which forms the State of Kentucky's border with the State of Indiana. Fort Knox is situated at an elevation 477 ft. above sea level lying in an area of Kentucky consisting of rolling hills and decidious forests. The mean temperature in January, the coldest month, is 33° F. with an average minimum of 25° F and an average maximum of 41° F. Of the summer months, July is normally the hottest, with a mean temperature of 77° F., an average minimum of 67° F. and an average maximum of 87° F. Average annual rainfall is 44.1 inches with a mean snowfall per year of 17 inches. The annual mean percentage of possible sunshine for Louisville, Kentucky, is 59. This figure is based on a period of record through December 1959. Mean percentage by month may be found in "ASHRAE Transactions 1974, Volume 80, Part II".

The installation is 172 sq. miles (110,000 acres) in gross area with the cantonement comprising an area of approximately 5 sq. miles.

The State of Kentucky normally ranks 2nd among the states in production of bituminous coal. Kentucky also produces significant quantities of petroleum and natural gas, but coal accounts for by far the greatest part of the total mineral value.

4.1.2 Existing Facilities

4.1.2.1 Physical Plant

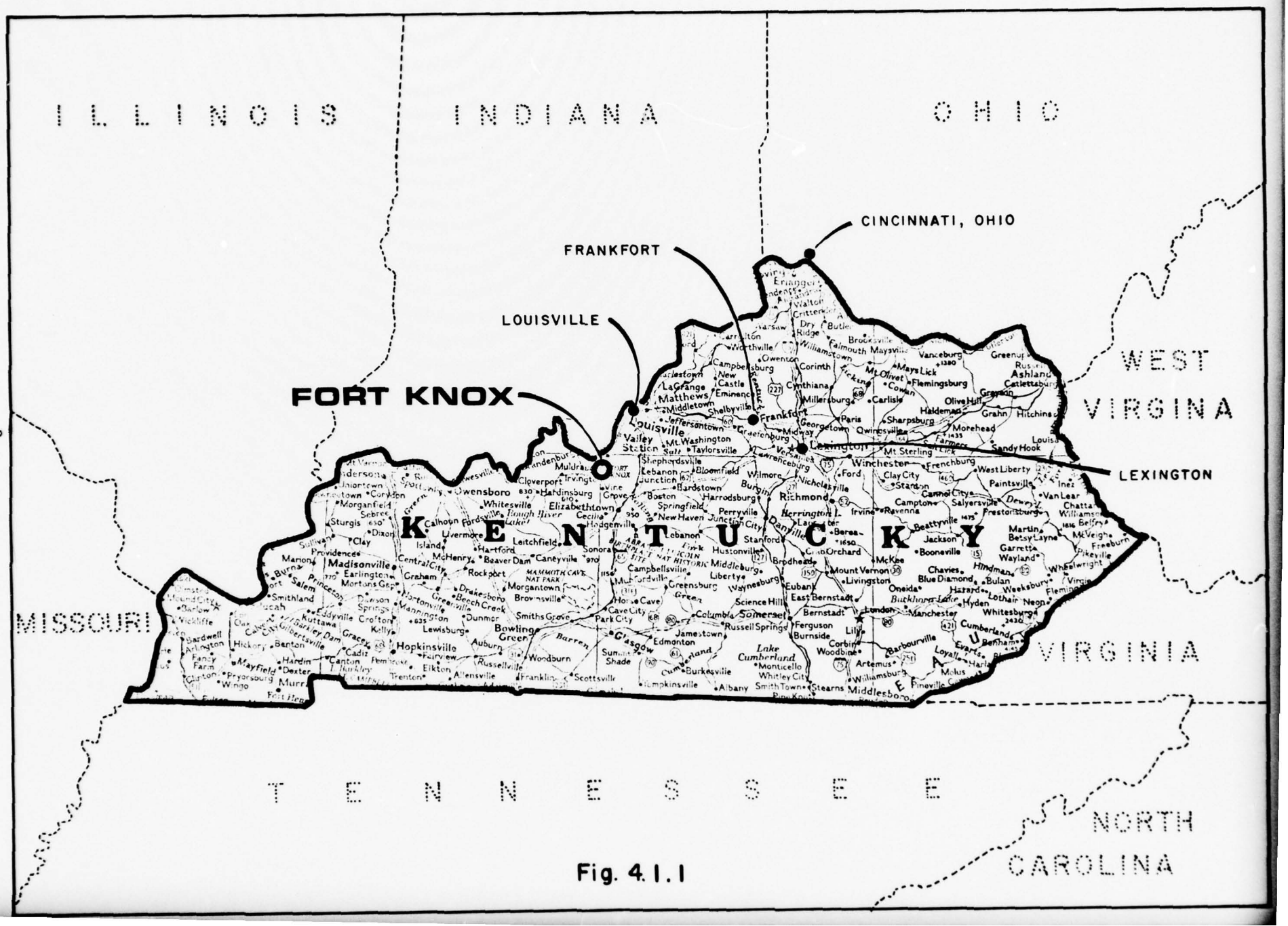
ILLINOIS
INDIANA
OHIO
WEST VIRGINIA
VIRGINIA
TENNESSEE
NORTH CAROLINA
MISSOURI
CINCINNATI, OHIO
FRANKFORT
LOUISVILLE
FORT KNOX
LEXINGTON
KENTUCKY

Fig. 4.1.1

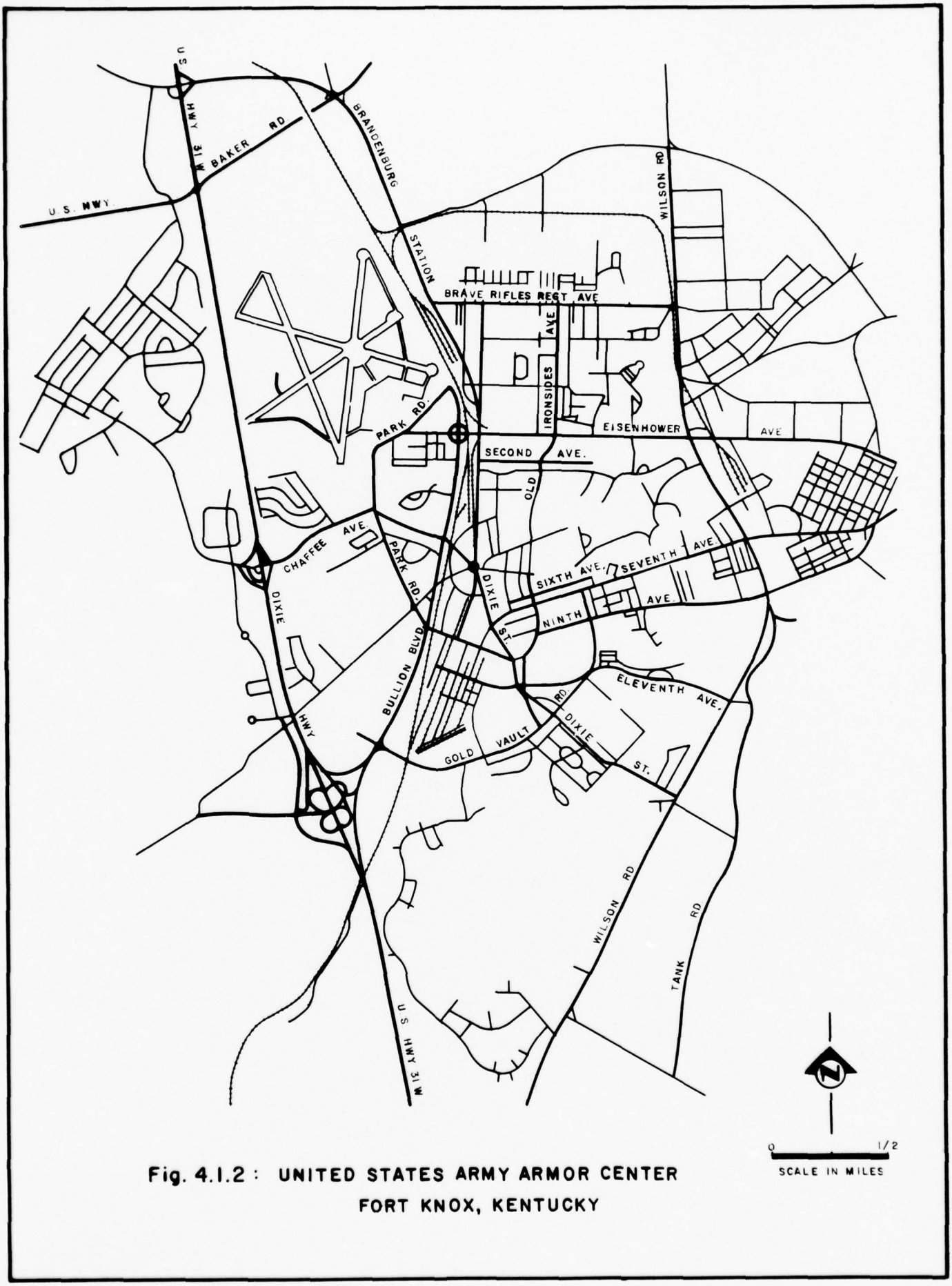

Fig. 4.1.2 : UNITED STATES ARMY ARMOR CENTER
FORT KNOX, KENTUCKY

Fort Knox represents approximately 14,000,000 sq. ft. of facilities comprising a total of 2496 buildings. Of these, 1040 represent multi-family housing units, 110 single-family housing units, 15-20 administrative buildings, the balance being barracks, shops and general store houses. The oldest buildings on the installation were built in 1918 with majority constructed in the 1930's and 1940's. Many of the multi-family housing structures were built in the mid 1950's.

4.1.2.2 Boiler, Heating and Air Conditioning Plants

There are a total of 502 boiler and heating plants on the installation. These plants have been divided into 4 classes. Table 4.1.1 lists these plants by class and fuel source. In all cases, the primary fuel of the dual fired plants is gas and the secondary fuel is oil. The plants are housed in some of the oldest and newest buildings on the installation. The five major plants include the laundry (Bldg.-T-17) and four central heating plants, located in Bldgs. 852, 2780, 5213 and 5943. These five facilities were constructed in 1942, 1957, 1959, 1941 and 1967 respectively. The largest of these central heating plants serves approximately 25 buildings. Most heating plants at Fort Knox are small and serve individual buildings or systems and there exists no large central heating plant at the base other than the four mentioned above.

One hundred ninety-five buildings on the installation are provided with comfort air conditioning either by building units or individual units. There are no central chiller plants at Fort Knox, and only one cold storage plant.

4.1.3 Future Construction

At this time, approximately 970,000 square feet of new building construction is scheduled for completion at Fort Knox by 1985. Approximately

TABLE 4.1.1

SUMMARY OF BOILER PLANTS LOCATED AT FT. KNOX, KENTUCKY

FIRING FUEL	NUMBER OF BOILER PLANTS CLASS				
	1	2	3	4	TOTALS
OIL	18	14	24	2	58
GAS	10	5	66	220	301
COAL	0	0	7	32	39
DUAL	73	27	4	0	104
TOTALS	101[2]	46	101	254	502

1. Class 1 - High Pressure over 3.5 Mill BTU/hr

   Class 2 - Low Pressure over 3.5 Mill BTU/hr

   Class 3 - Low Pressure over 0.75 to 3.5 Mill BTU/hr

   Class 4 - Low Pressure under 0.75 Mill BTU/hr

2. Includes 25 high pressure plants below 3.5 Mill BTU/hr

1,350,000 square feet of existing buildings are scheduled for demolition by 1985. Although this planning will result in a net reduction of 380,000 square feet in building area (2.7% of the total post building area) no proportional reduction in post energy consumption is expected. The majority of the buildings scheduled for demolition are non-air conditioned enlisted personnel barracks, while the majority of the new facilities will be more energy-intensive having air conditioning and more intensive lighting and utilizing more electrical appliances. For this reason, it is projected that the post energy consumption will increase approximately 10 percent by 1985 if no energy conservation programs are initiated.

4.2 Facility Energy Sources

4.2.1 Types Utilized

Fort Knox presently utilizes five types of fuel to provide its non-transportation energy requirements. These types of fuel and the respective percentage of the total post non-transportation energy consumption for FY 76 as recorded by the Environmental and Energy Conservation Branch at the post are as follows:

Type of Fuel	% of Total Post Energy Consumption
Natural Gas	54.29%
Electricity	34.79%
Fuel Oil	10.02%
Coal	0.63%
L. P. Gas	0.27%
Total	100.00%

Of the total quantity of these fuels consumed in the State of Kentucky, Fort Knox consumes the following percentage:

Type of Fuel	
Natural Gas	1.25%
Electricity	0.00025%
Fuel Oil	0.697%
Coal	0.00392%
L. P. Gas	0.055%

On a regional basis, Fort Knox consumes 3.45% of the total output of its natural gas supplier, Louisville Gas and Electric Company (LG&E), and 1.9% of the total electrical output of LG&E.

Although, significant quantities of coal are mined in Kentucky, none is mined within the boundary of the reservation. A large volume of

underground natural gas storage lies within the boundaries of the installation. At this time, this underground storage is leased to the Louisville Gas and Electric Company for a very nominal fee.

On-site generation of electricity is limited to the emergency requirements for the Hospital with additional portable generators for emergency use. A total of 1900 KW in emergency generator capacity is available.

There are no Corps of Engineers hydro-electric dams in this part of the state.

Figures 4.2.1 through 4.2.7 show annual and monthly fuel energy consumption at Fort Knox. It is apparent from the total annual energy consumption data for the post (Figure 4.2.2) that peak consumption of all energy sources occurs during winter months at an approximate value of 500 x 10^9 Btu/month. Minimum monthly consumption occurs during summer months at approximately 120 x 10^9 Btu/month. Consumption of oil, natural gas, coal, and LP gas follows this general trend. However, consumption of electricity peaks during the summer months at 50 x 10^9 Btu/month (as shown in Figure 4.2.3). This contrasts to minimum monthly electric power consumption occurring during spring and fall months at a value of 30 x 10^9 Btu/month. The increased electrical power consumption during summer months most probably reflects air conditioning loads incurred during those months.

4.2.2 Facility Energy Costs

The unit costs of the five energy sources (natural, gas, electricity, fuel, oil, coal and LP) range from a high of $4.90/mill Btu for electricity to a low of $0.76/mill Btu for coal. A comparison of unit costs per million Btu's in FY 76 may be found in Figure 4.2.8.

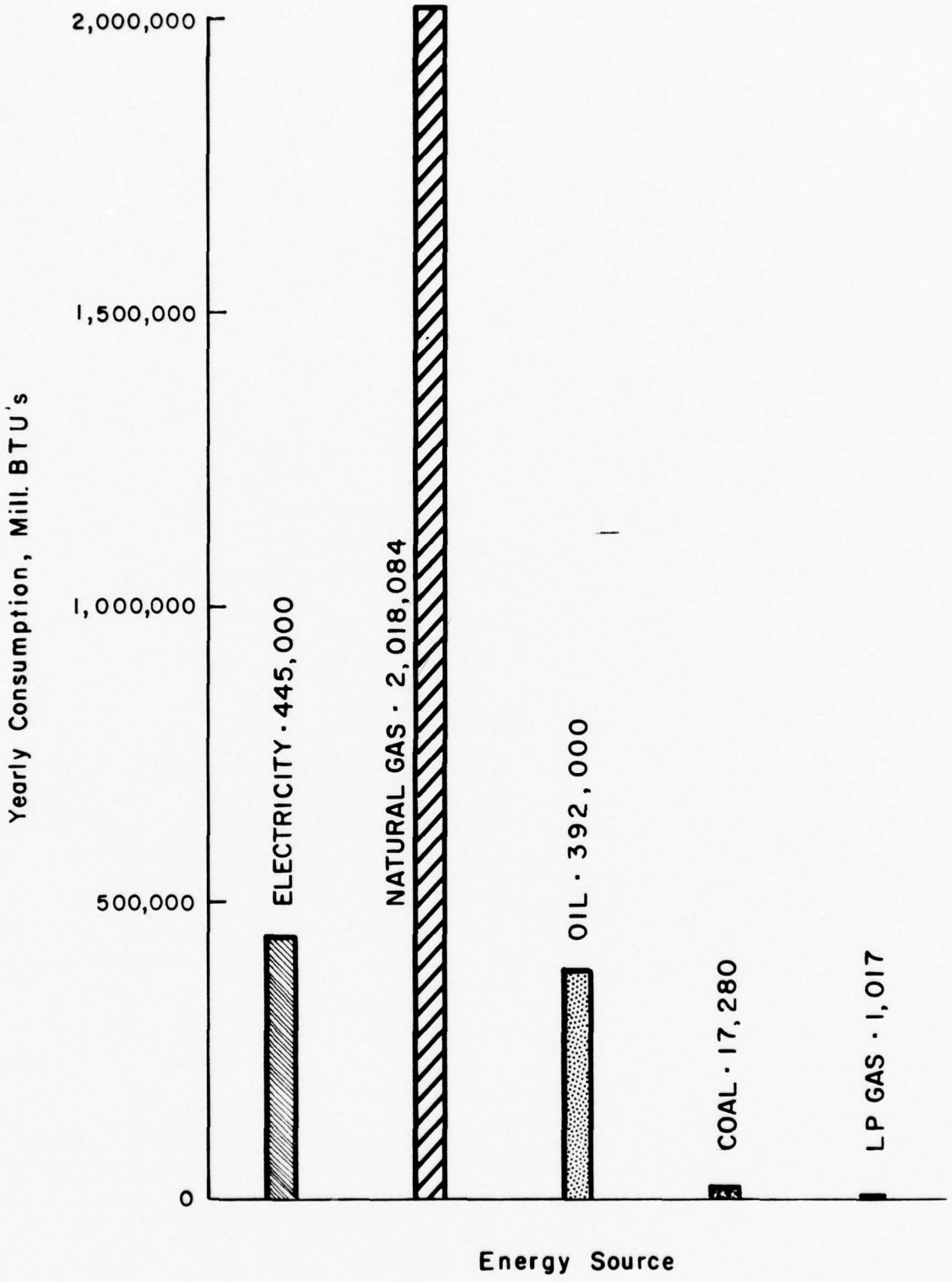

Fig. 4.2.1: Bar Diagram Showing Yearly Consumption of Sources of Energy at Ft. Knox During FY 76

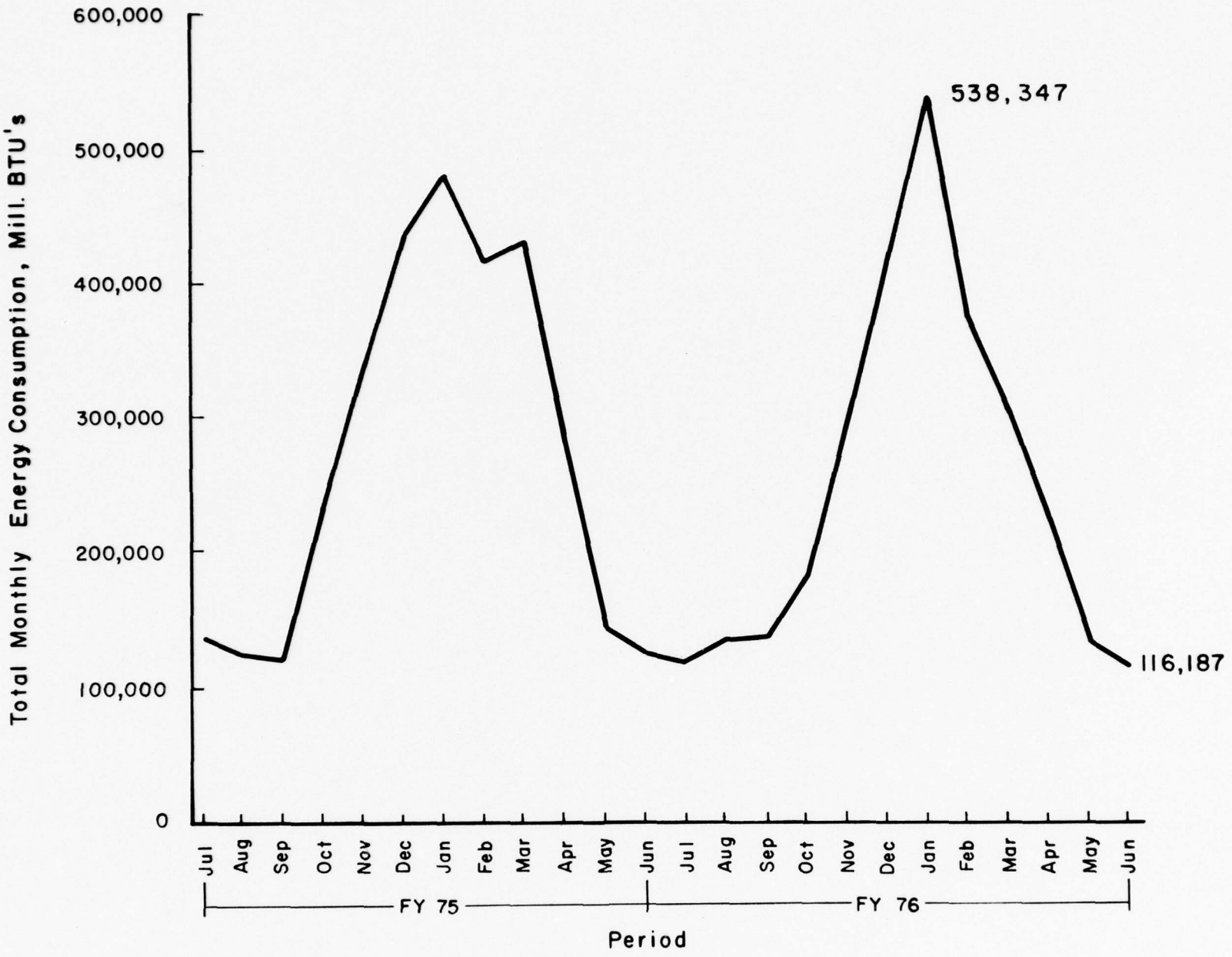

Fig. 4.2.2 : Total Monthly Energy Consumption at Fort Knox During FY 75 and FY 76

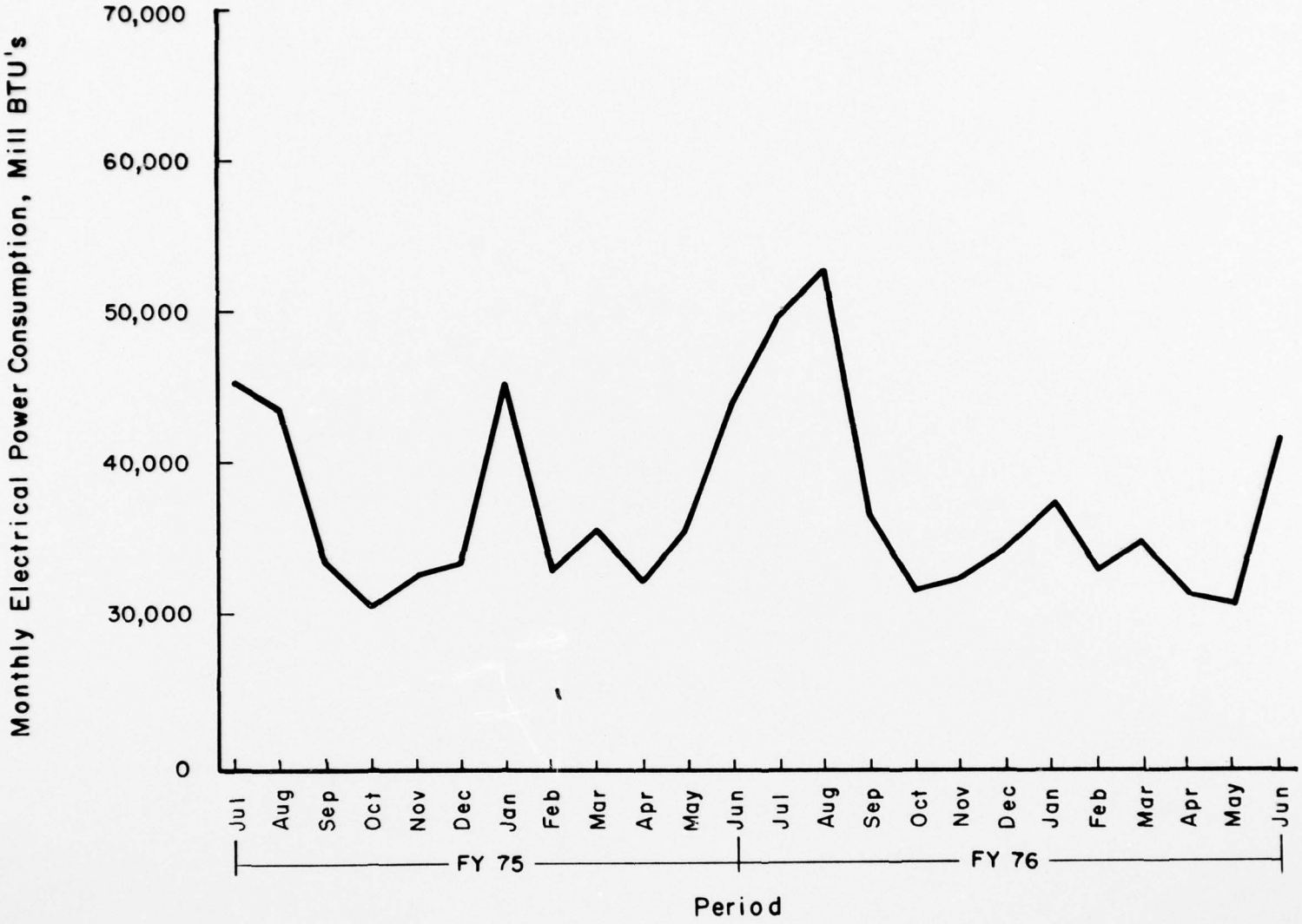

Fig 4.2.3 : Monthly Electrical Power Consumption at Fort Knox During FY 75 and FY 76

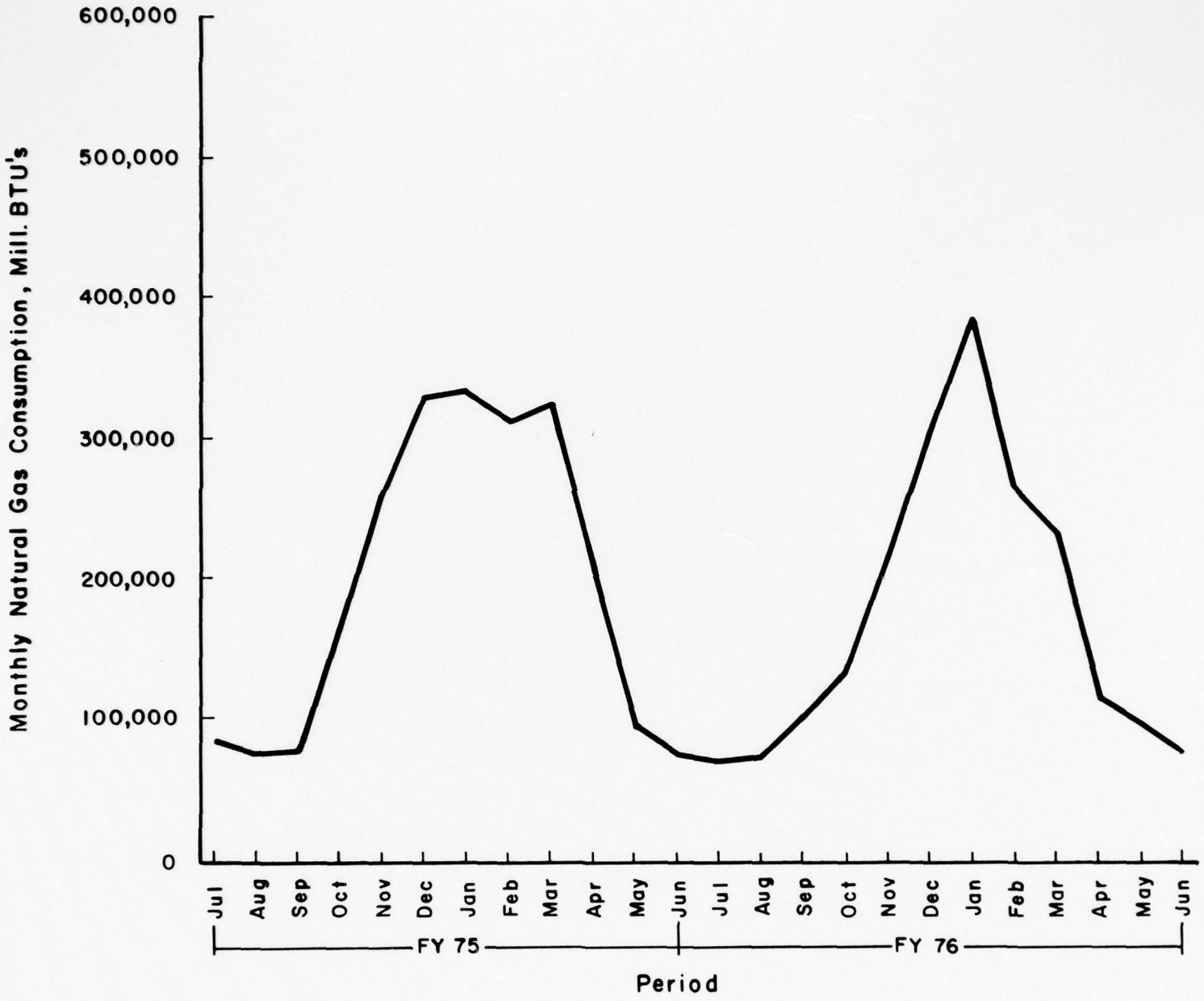

Fig. 4.2.4 : Monthly Natural Gas Consumption at Fort Knox During FY 75 and FY 76

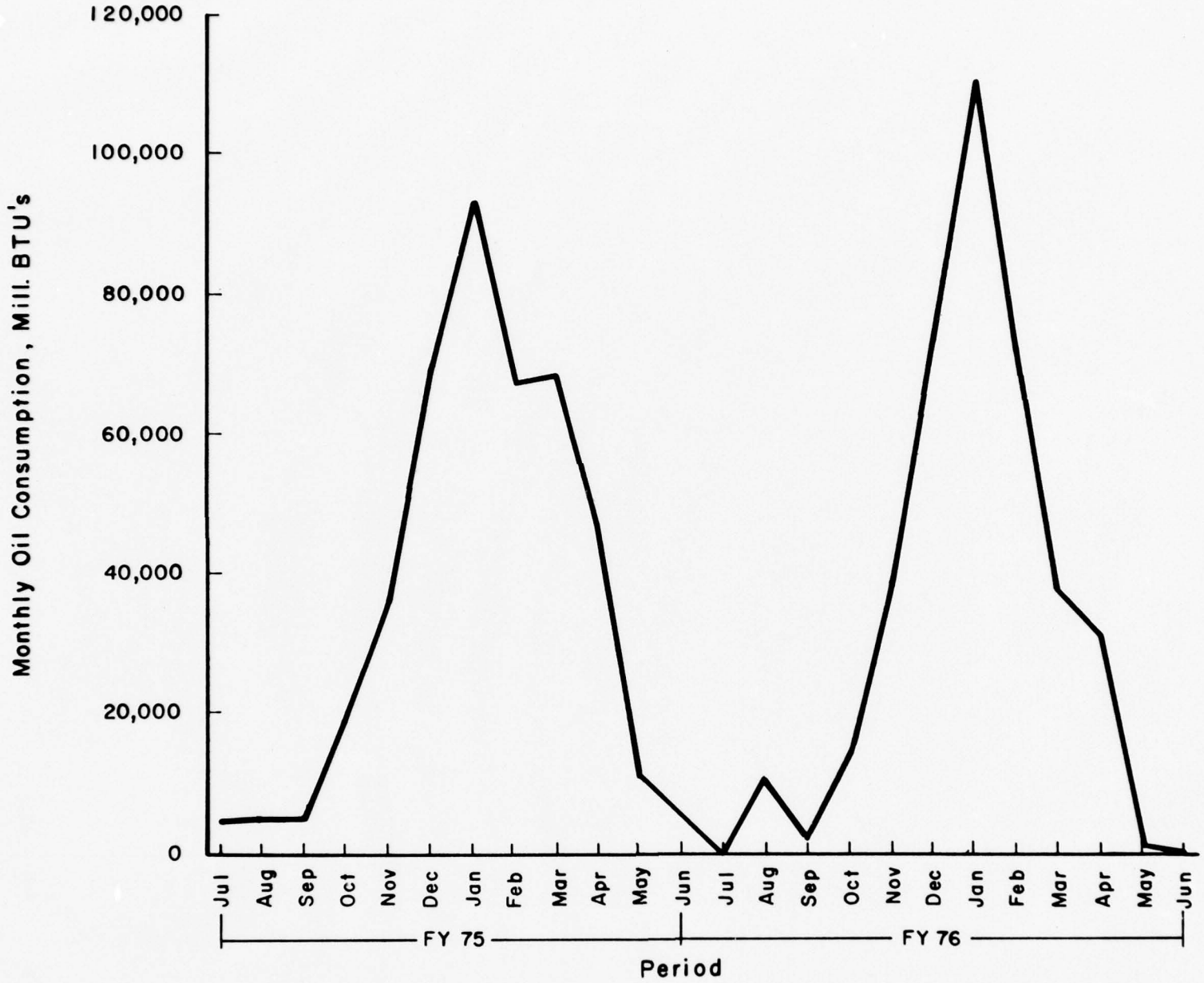

Fig. 4.2.5 : Monthly Oil Consumption at Fort Knox During FY 75 and FY 76

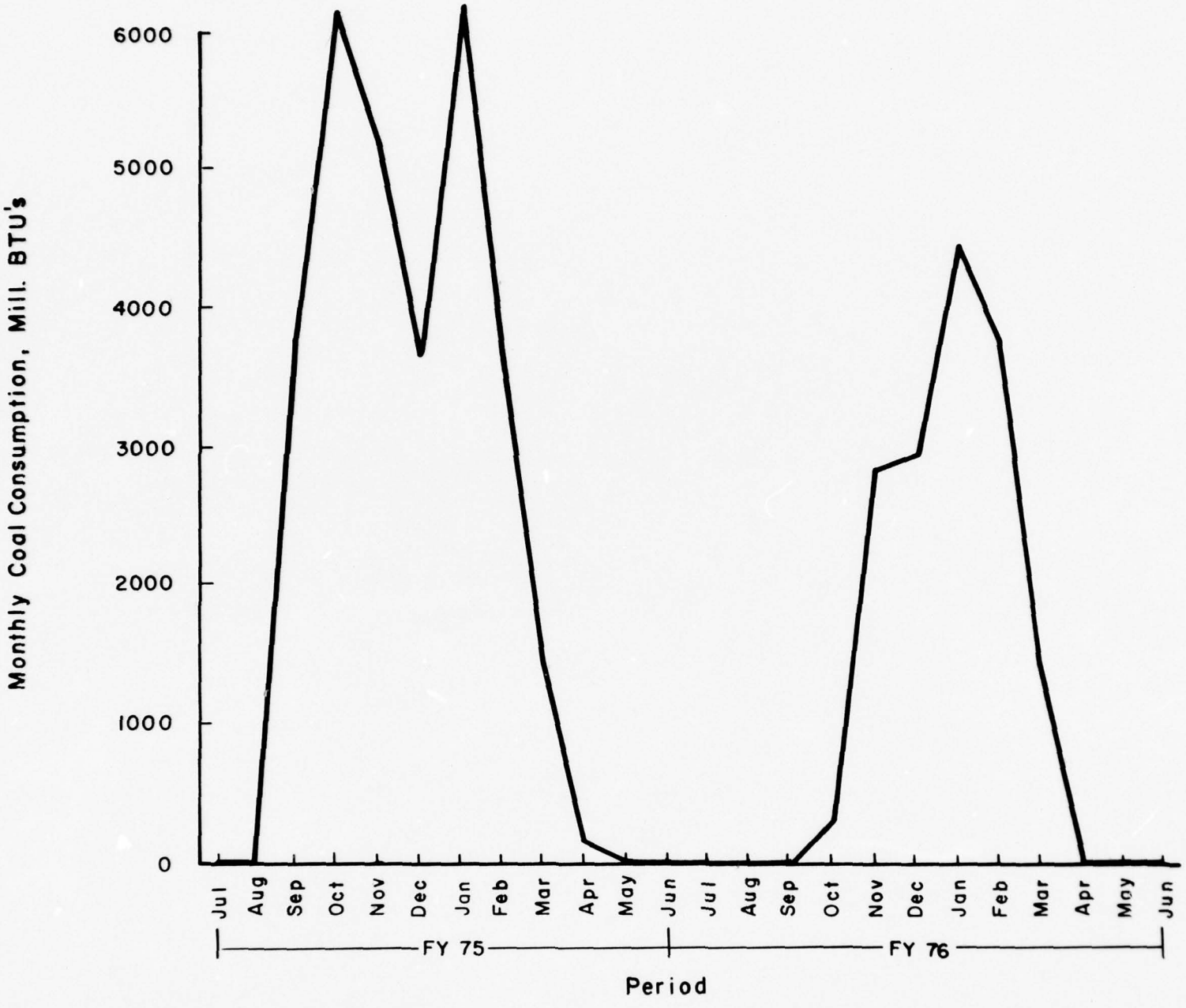

Fig. 4.2.6 : Monthly Coal Consumption at Fort Knox During FY 75 and FY 76

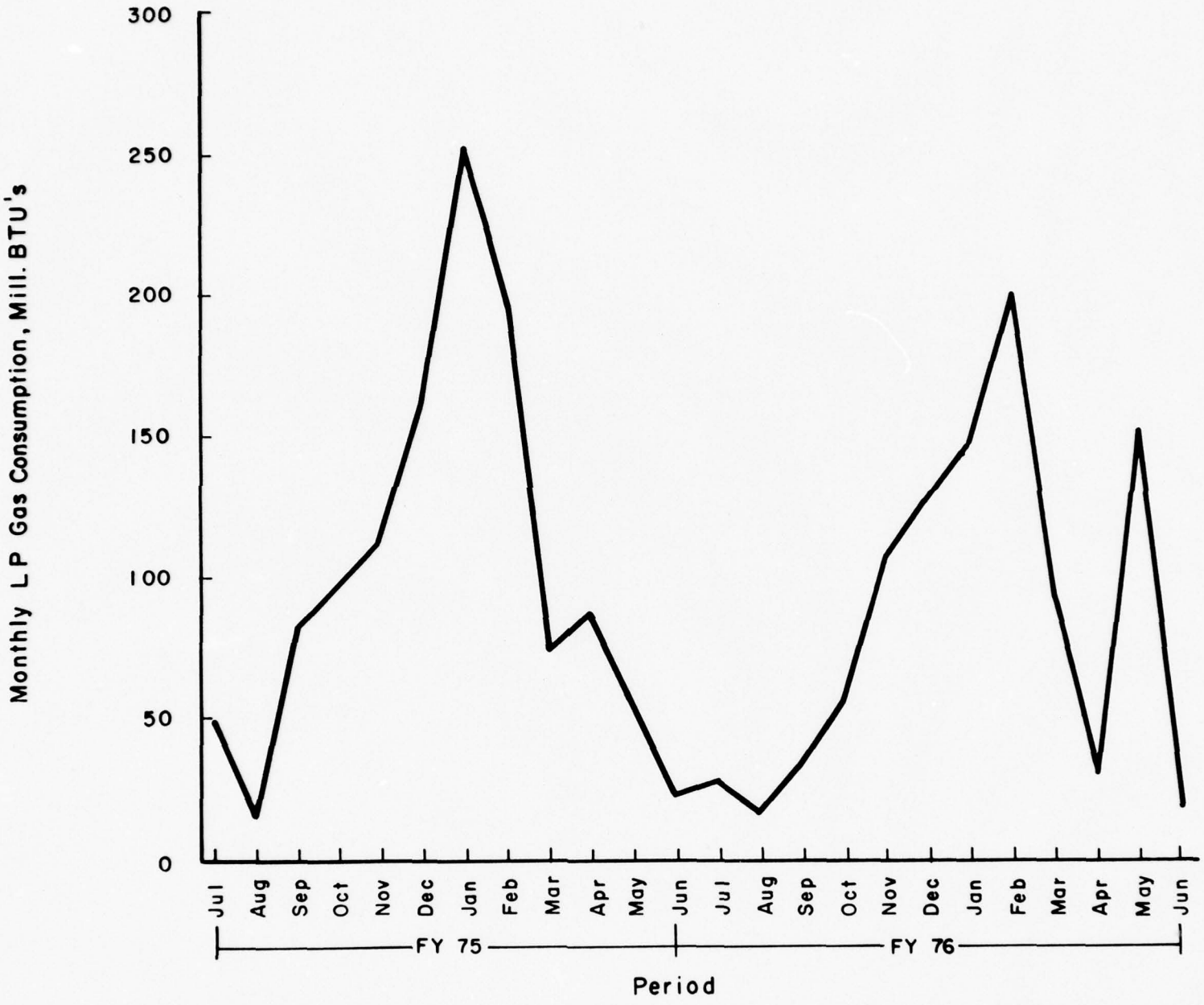

Fig. 4.2.7 : Monthly LP Gas Consumption at Fort Knox During FY 75 and FY 76

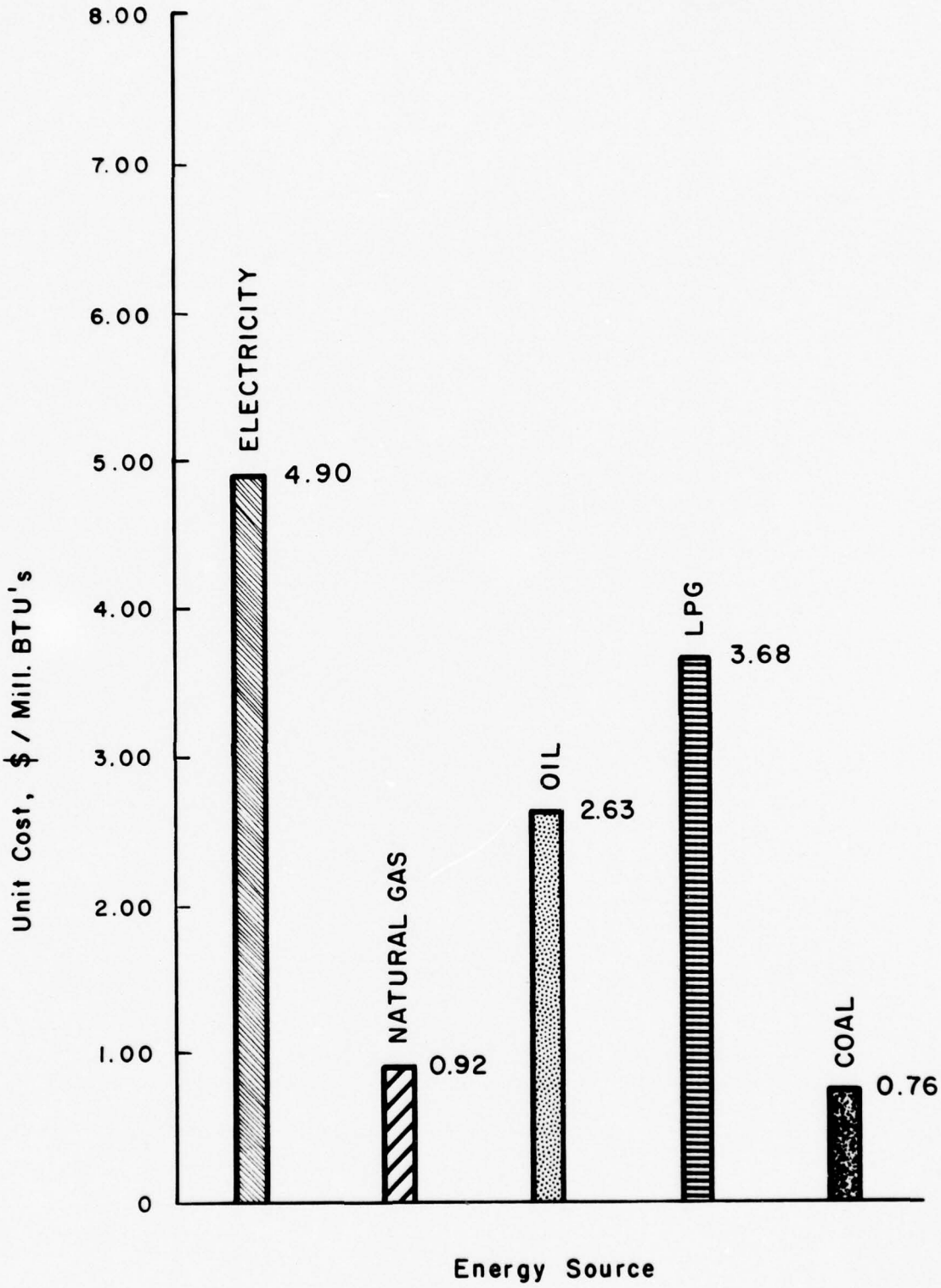

Fig. 4.2.8 : Unit Cost of Energy at Fort Knox During FY 76

Figure 4.2.9 is a bar diagram showing the total costs paid by Fort Knox for different forms of energy in FY 76. It can be seen that the installation paid almost $5.1 million in FY 76 for energy.

Figure 4.2.10 graphs the heating and cooling degree days at Fort Knox from 1951 to 1975. It is apparent from this figure that the last five winters have been considerably warmer than normal. Assuming no increase over the present levels in the price per million Btu's of the energy sources at Fort Knox, the installation can expect to pay more for its energy in the next several years when the winter weather returns to a more normal temperature pattern. A more normal winter temperature pattern would increase heating energy consumption 11% over 1971 through 1975 levels.

Energy cost projections through 1985 indicate that the amount of energy used by the post in FY 76 would cost over three times as much in 1985.

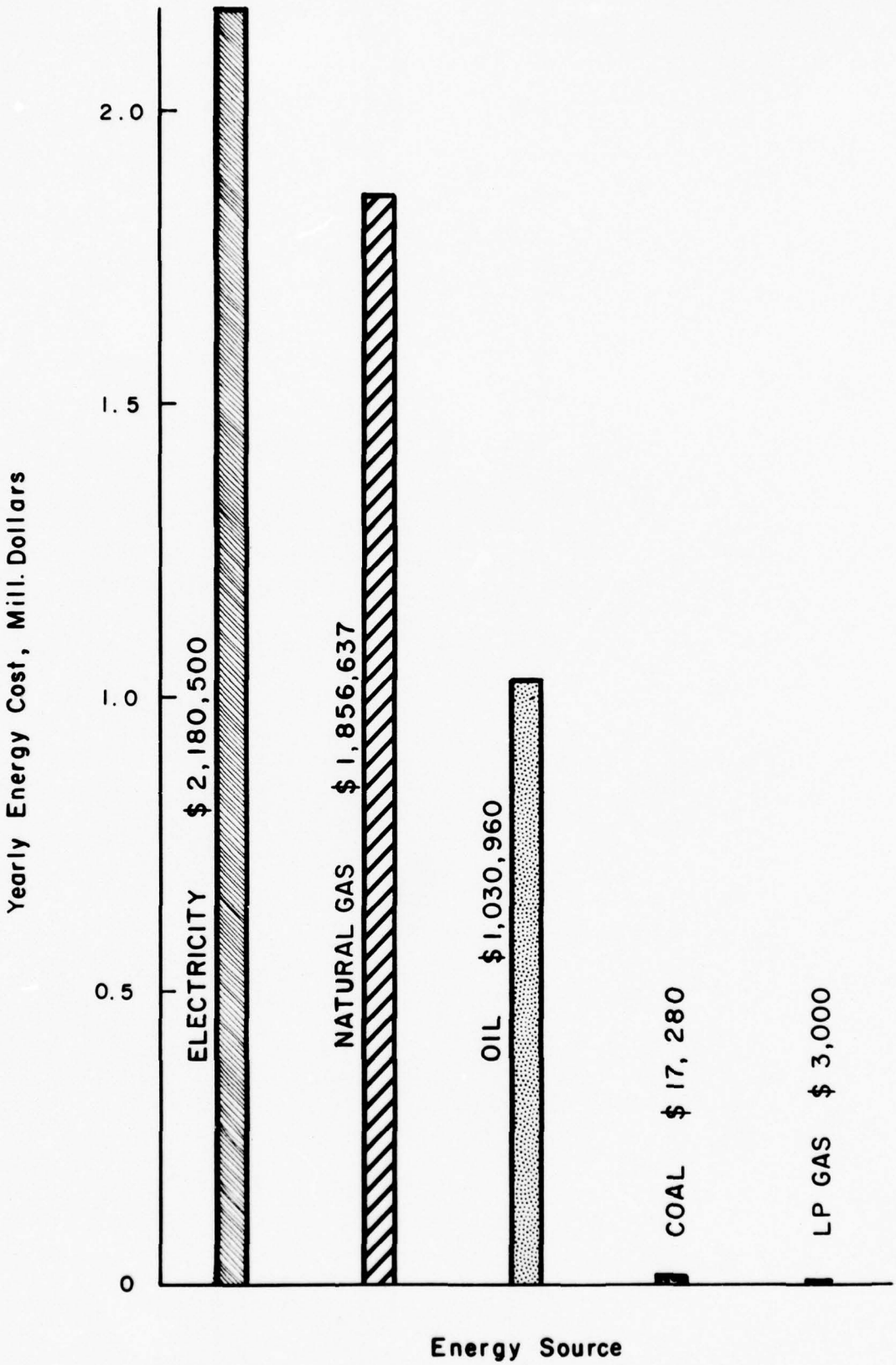

Fig. 4.2.9 : Yearly Energy Cost at Fort Knox During FY 76

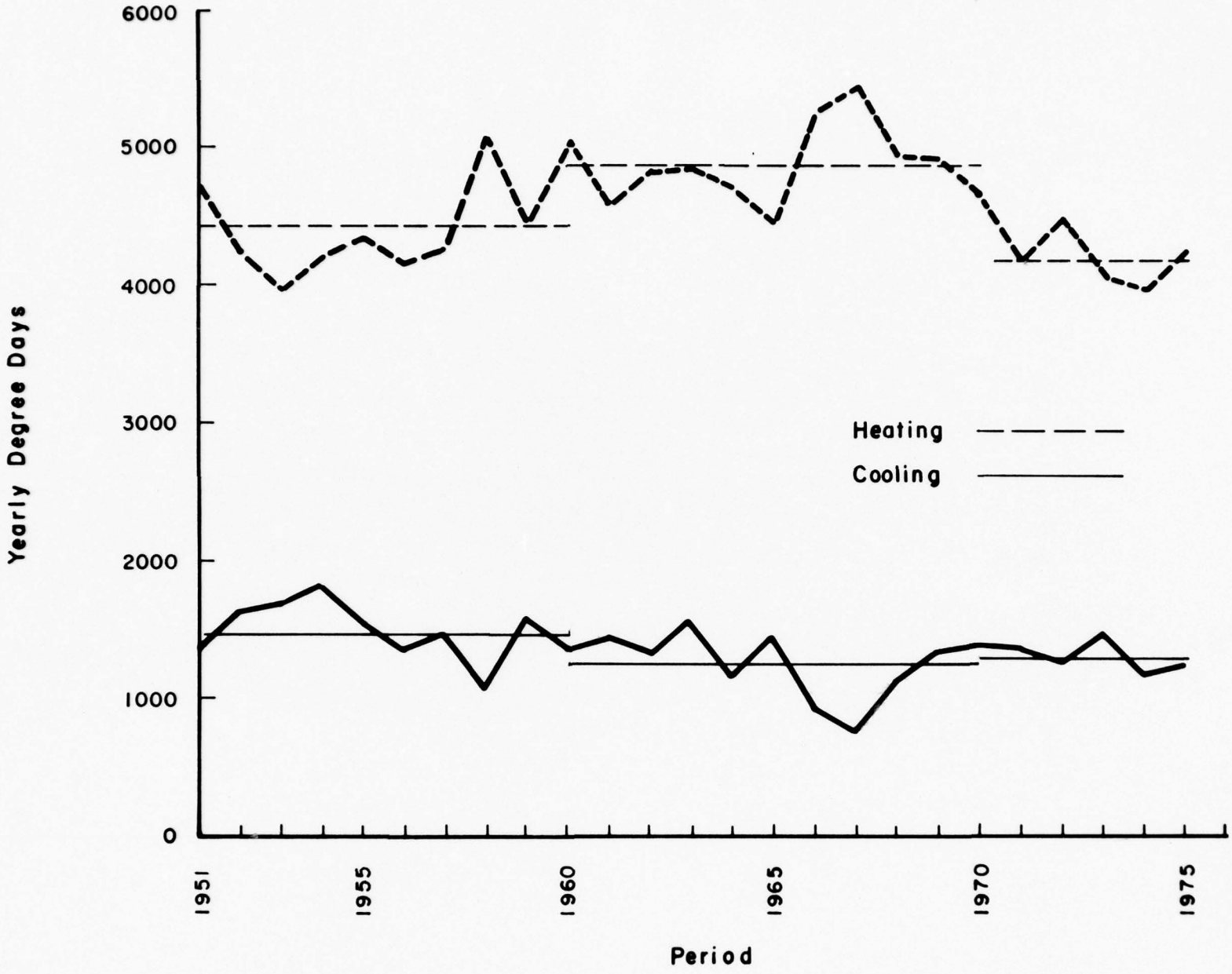

Fig. 4.2.10: Heating and Cooling Degree Days 1951 - 1975

5. REGIONAL IMPACT OF FACILITY ENERGY USAGE

5.1 Fuel Oil

5.1.1 Consumption

Data in Table 5.1.1 indicates that the 1977 consumption target for fuel oil at Fort Knox is 3,133,700 gallons or 74,600 barrels. This figure represents approximately 10% of the installation's energy requirements but only 0.7% of the fuel oil used in the entire State of Kentucky. Monthly oil consumption at Ft. Knox in million BTU's for FY75 - FY76 has been graphically presented in Figure 4.2.5. A comparison of FY75 and FY76 yearly oil consumption and targeted FY77 consumption is presented in Figure 5.1.1

Petroleum products account for slightly more than one-fourth of the energy consumed in Kentucky with three-fourths of this used in the transportation sector. While fuel oil utilization has been steadily rising in the State of Kentucky, oil production has been decreasing during recent years. For instance, crude oil production in Kentucky in 1964 represented 0.71% of the total U. S. production while in 1974 it dropped to 0.25%. Annual fuel oil production and consumption data for the State of Kentucky are summarized in Tables 5.1.2, 5.1.3 and 5.1.4.

5.1.2 Usage

The fuel oil at Ft. Knox is used for general comfort heating and as the secondary fuel for process loads. There are also approximately 13 fixed emergency generators that use No. 2 oil as their fuel.

The heating and boiler plants at Ft. Knox have been divided into four classes as follows:

Class 1 - High Pressure over 3.5 Mill BTU/hr - Boiler Plant

Class 2 - Low Pressure over 3.5 Mill BTU/hr - Heating Plant

TABLE 5.1.1

FORT KNOX

HEATING FUELS MONTHLY ENERGY TARGETS

FY 77

MONTH	NORMAL DEGREE DAYS		NATURAL GAS		ELECTRIC		FUEL OIL		COAL		LP GAS		TOTAL ENERGY
	Cooling	Heating	10^6CF	10^9BTU	10^9WH	10^9BTU	10^3Gal	10^9BTU	Tons	10^9BTU	10^3Gal	10^9BTU	10^9BTU
Oct	37	227	132.5	136.611	9.296	107.83	109.0	15.11	250	6.145	9.98	.953	266.649
Nov	3	573	270.26	278.64	9.247	107.27	303.0	42.03	211	5.186	11.90	1.136	434.262
Dec	0	865	350.34	361.2	9.785	113.51	575.5	79.82	151	3.704	13.52	1.291	559.525
Jan	0	978	380.37	392.16	10.568	122.59	780.0	108.19	216	5.309	26.52	2.533	630.782
Feb	0	802	330.32	340.56	9.932	115.21	606.0	84.05	144	3.539	20.65	1.972	545.331
Mar	3	630	280.27	288.96	9.394	108.97	404.0	56.03	57	1.401	13.79	1.317	456.678
Apr	32	284	160.16	165.12	9.100	105.56	222.2	30.82	5	.122	7.84	.749	302.371
May	107	91	96.02	99.0	9.785	113.51	50.5	7.00	0	0	5.90	.563	220.073
Jun	255	9	72.74	75.0	12.623	146.43	30.475	4.23	0	0	2.50	.239	225.899
Jul	340	1	71.78	74.0	14.188	164.58	17.675	2.45	0	0	.52	.050	239.56
Aug	342	2	70.30	72.48	14.482	167.99	17.675	2.45	0	0	.18	.017	244.457
Sep	173	43	69.84	72.0	11.742	136.21	17.675	2.45	83	2.04	8.80	.840	213.54
	1292	4505	2284.90	2355.731	130.142	1509.66	3133.700	434.63	1117	27.446	122.10	11.660	4339.127
	Percent (%) of Total =			54.29%		34.79%		10.02%		0.63%		0.27%	100.00%

Provided by Environmental and Energy Conservation Branch, Fort Knox, Kentucky

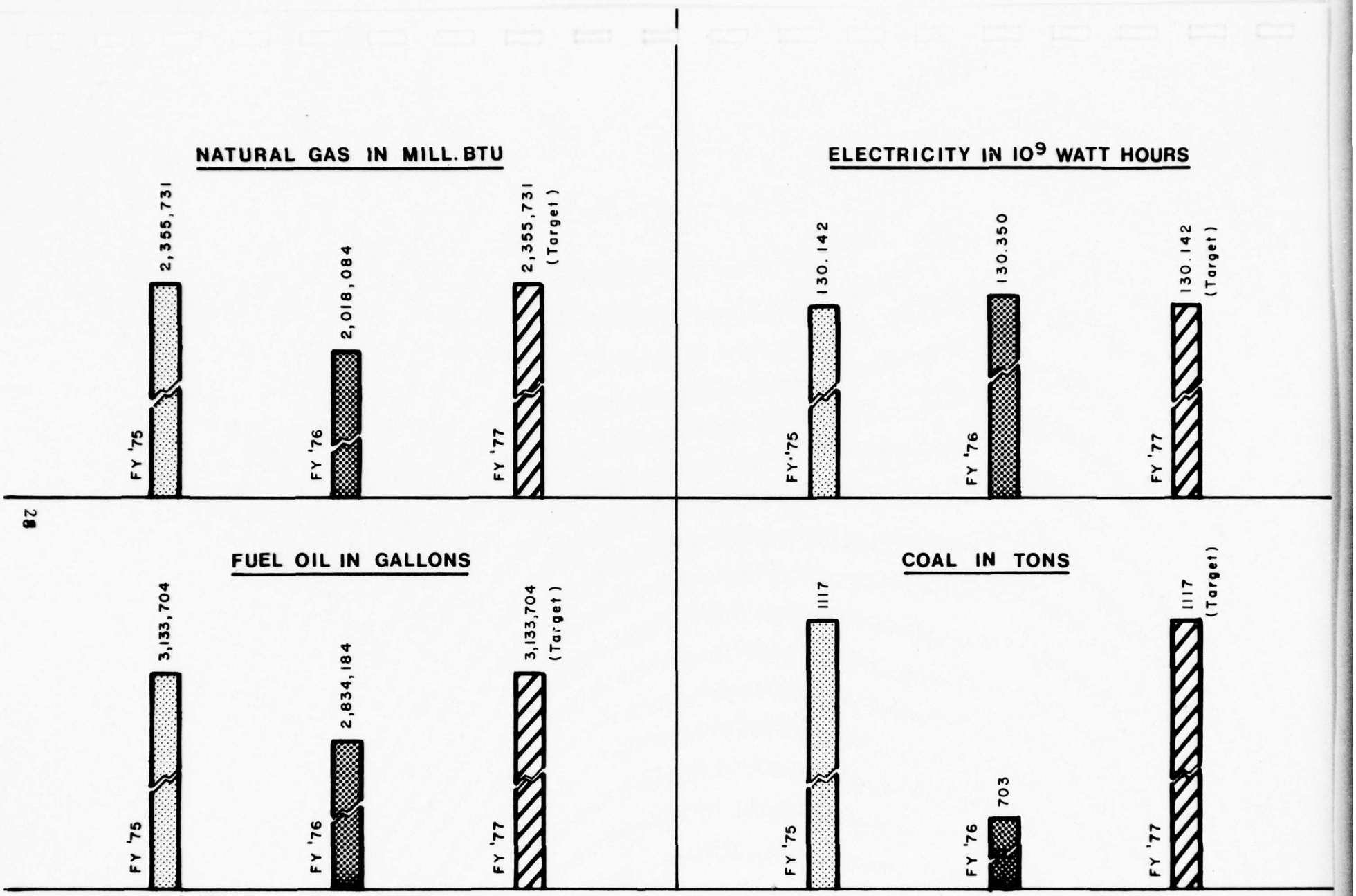

Fig. 5.1.1 : Fort Knox Energy Consumption Comparisons For Fiscal Year 1975 & 1976 With Fiscal Year 1977 Target Consumption

TABLE 5.1.2

U.S. AND KENTUCKY CRUDE OIL PRODUCTION[1]
AND PRODUCING OIL WELLS, 1947-1974
(Thousand Barrels)

Year	Crude Oil Production		Producing Wells	
	Kentucky	U.S.	Kentucky	U.S.
1947	9,397	1,856,987	14,780	426,280
1948	8,801	2,020,185	14,750	437,880
1949	8,803	1,841,940	15,500	448,680
1950	10,381	1,973,574	15,650	465,870
1951	11,622	2,247,711	16,900	474,990
1952	11,918	2,289,836	16,950	488,520
1953	11,518	2,357,082	16,600	498,940
1954	13,791	2,314,988	16,900	511,200
1955	15,518	2,484,428	17,800	524,010
1956	17,628	2,617,283	18,660	551,170
1957	17,029	2,616,901	18,260	569,273
1958	17,509	2,448,987	18,965	574,905
1959	27,272	2,574,590	21,165	583,141
1960	21,147	2,574,933	20,571	591,158
1961	18,344	2,621,758	19,857	594,917
1962	17,789	2,676,189	19,448	596,385
1963	18,344	2,752,723	14,903	588,657
1964	19,772	2,786,822	15,226	588,225
1965	19,386	2,848,514	15,600	589,203
1966	18,066	3,027,763	14,800	583,302
1967	15,535	3,215,742	13,255	565,289
1968	14,036	3,329,042	12,311	553,920
1969	12,924	3,371,751	11,843	542,227
1970	11,575	3,517,450	11,659	530,990
1971	10,692	3,453,914	14,657	517,318
1972	9,702	3,455,368	14,616	508,443
1973	8,687	3,360,903	14,416	497,378
1974[p]	7,837	3,199,328	14,127	497,631

[1] Includes Lease Condensate
[p] Preliminary for crude oil production.

SOURCE: U.S. Bureau of Mines, Petroleum Statement, Annuals.

TABLE 5.1.3

KENTUCKY DISTILLATE FUEL OIL UTILIZATION BY SECTOR, 1968-1975
(Thousands of Barrels)

Sector	1968	1969	1970	1971	1972	1973	1974	1975
Heating	1,864	1,818	2,152	1,576	1,550	1,655	1,613	1,825
Transportation								
Highway[1]	2,093	2,932	2,604	1,927	3,494	3,956	3,682	3,482
Non-Highway[2]	1,881	2,095	2,126	2,104	2,128	2,335	2,224	2,659
Industrial[3]	638	682	733	1,035	1,032	1,109	1,150	1,237
Electric Utilities[4]	1	--	7	7	57	28	85	109
Miscellaneous[5]	827	878	587	1,127	1,337	1,374	1,422	1,648
Total	7,304	8,405	8,209	7,882	9,598	10,457	10,176	10,960

[1]Diesel

[2]Railroads and vessel-bunkering.

[3]Includes oil company use.

[4]Beginning in 1972, distillate fuel oil used at steam-electric plants was included. This use was reported by Bureau of Mines as residual fuel oil in prior years. Also, kerosene-type jet fuel used by electric utility companies was reported for the first time in 1972.

[5]Includes off-highway diesel and fuels used by military, etc.

SOURCE: U.S. Bureau of Mines, Mineral Industry Surveys, Sales of Fuel Oil and Kerosene, 1968-1975.

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TABLE 5.1.4

KENTUCKY RESIDUAL FUEL OIL UTILIZATION BY SECTOR, 1968-1975
(Thousands of Barrels)

Sector	1968	1969	1970	1971	1972	1973	1974	1975
Heating	21	103	116	128	152	211	315	769
Transportation[1]	160	138	145	49	4	3	2	2
Industrial[2]	649	757	745	225	670	759	1,579	1,856
Electric Utilities[3]	12	35	121	271	333	121	188	--
Miscellaneous	8	10	34	1	--	--	--	--
Total	850	1,043	1,161	674	1,159	1,094	2,084	2,627

[1]Railroads and vessel bunkering.

[2]Includes oil company use.

[3]Before 1972, included distillate fuel oil used at steam-electric plants. In 1972 and after, this use was reported as distillate fuel oil.

SOURCE: U.S. Bureau of Mines, Mineral Industry Surveys, Sales of Fuel Oil and Kerosene, 1968-1975.

Class 3 - Low Pressure over 0.75 to 3.5 Mill BTU/hr - Heating Plant

Class 4 - Low Pressure under 0.75 Mill BTU/hr - Heating Plant

Table 4.1.1 summarizes pertinent data concerning the boiler and heating plants at Ft. Knox. Oil is used as the primary and only fuel in 58 of the 502 boiler and heating plants on the installation. However, fuel oil serves as the secondary fuel in 104 of the boiler and heating plants with natural gas being the primary fuel. The criteria for changing from the primary to secondary is an outside air temperature of 25° F. or less. However, due to Louisville Gas & Electric Co.'s curtailment of non-domestic use of natural gas at Fort Knox, more oil will be utilized in FY77. Louisville Gas & Electric defines non-domestic gas usage as that natural gas not used for comfort heating.

Buildings 5943 and 5213 are the only central boiler plants on the installation that utilize fuel oil exclusively. These plants have a total capacity of 52,000 Million BTU/hr and 16,800 Million BTU/hr respectively, and they supply hot water or steam to approximately 31 buildings. Building 5943, Disney Heating Plant, which is the largest plant by capacity, burns approximately 390,500 gallons of fuel oil in a twelve month period. This represents approximately 12 percent of the installation's yearly oil requirements. All fuel oil used at Ft. Knox is No. 2.

5.1.3 Availability and Cost

Ft. Knox oil is trucked to the installation by a supplier who is selected through a bidding process, by the U. S. Army General Material and Petroleum Activity at New Cumberland, Pennsylvania. The supplier delivers the oil, by truck as noted, to the installation and fills the larger tanks

located on the installation. The remainder of the small tanks are filled by military personnel who draw from the larger tanks.

The $0.36/gallon fuel oil cost to Fort Knox was established, by contract, by the Material and Petroleum Activity. Since Fort Knox is not involved in the original contract negotiations, the installation cannot directly influence the pricing schedule.

Although Kentucky produces approximately 3,000,000 barrels per year of crude oil, the state utilizes approximately 13,600,000 barrels per year of distillate and residual fuel oils. Therefore, the State of Kentucky, including Fort Knox, must rely on outside sources and refineries.

5.1.4 Storage Capacity

There is approximately 800,000 gallons of fuel oil storage capacity at Fort Knox. This storage volume is composed of a large number of small tanks and tank combinations, the largest of which is approximately 100,000 gallons. This 800,000-gallon capacity has been estimated by the Knox operating personnel to represent a 30-day supply at normal consumption rates. However, with the curtailment of natural gas, as explained previously, and the possibility of colder winters this will mean the burning of more fuel oil, such that the 800,000-gallon capacity could represent somewhat less than a 30-day supply.

5.2 Natural Gas

5.2.1 Consumption

Natural gas provides nearly one-third of the nation's primary energy. The State of Kentucky uses slightly over one percent of the natural gas consumed in the U. S. (Table 5.2.1) and produces approximately 0.3 percent of the total U. S. marketed production (Table 5.2.2). In 1975 Ft. Knox used approximately 1.25 percent of the natural gas consumed in Kentucky. However, natural gas has comprised over 50 percent of the installation's energy requirements for several years (54.29% FY77 target - Table 5.1.1).

5.2.2 Usage

Fort Knox consumes the greatest amount of its yearly natural gas supply during the winter months. (See Figure 4.2.4). The greatest use of natural gas is in Class 2, 3 and 4 Heating Plants. (See Figure 5.2.1). Utilization of these plants is governed by the Fort Knox utilities/energy conservation policy for the FY77 cold weather season. This policy is defined by the Fort Knox adjutant general (References AR 11-27, Army Programs - Energy Program and AR 420-44, Facilities Engineering - Utilities Management Analysis, with TRADOC Supl 1, and USAARMC Supl 1 with changes 2 through 5). The policy establishes the heating season from 15 October to 30 April, building temperature restrictions, family housing heating thermostat settings, heating thermostat night set backs and settings for periods of non-occupancy and prohibition of portable electric heaters.

5.2.3 Supplier

Natural gas for the Louisville area and Fort Knox is supplied by the Louisville Gas and Electric Company (LG&E) and is pipeline limited with controls on quantity and cost. Refer to Figure 5.2.2 for Louisville Gas and Electric service area.

TABLE 5.2.1

NATURAL GAS CONSUMPTION IN KENTUCKY BY SECTOR, 1950-1975
(Millions of Cubic Feet at 14.73 psia)

Year	Residential	Commercial	Industrial[1]	Electrical	Other	Total[1]	Ky. as % of U.S.
1950	26,048	7,580	24,438	3,257	---	61,323	1.02
1951	32,022	9,167	30,956	2,241	---	74,386	1.05
1952	32,839	9,497	40,907	3,763	---	87,006	1.14
1953	33,739	9,879	50,413	10,750	---	104,781	1.31
1954	37,388	11,011	52,437	9,203	---	110,039	1.31
1955	40,719	12,558	58,176	6,043	---	117,496	1.30
1956	43,662	13,358	64,714	4,846	---	126,580	1.30
1957	46,790	13,340	66,241	6,065	---	132,436	1.29
1958	55,046	15,943	61,225	4,776	---	136,990	1.27
1959	58,002	16,640	69,802	3,549	---	147,993	1.25
1960	63,009	18,264	76,149	2,288	---	159,710	1.28
1961	58,941	22,959	78,070	1,942	---	161,912	1.24
1962	61,956	24,396	80,132	1,654	---	168,138	1.21
1963	64,679	25,369	84,589	1,291	---	175,928	1.20
1964	66,252	20,935	97,454	1,139	---	185,780	1.20
1965	64,094	21,343	96,938	453	---	182,828	1.14
1966	54,310	19,025	86,114	943	---	160,392	.93
1967	69,542	25,698	59,421	380	6,615	161,656	.94
1968	75,824	28,667	51,969	349	7,422	164,231	.98
1969	83,815	32,741	65,639	7,013	9,193	198,401	1.10
1970	86,473	33,970	72,524	8,533	8,491	209,991	1.10
1971	84,197	32,697	71,484	8,910	9,655	206,943	1.05
1972	85,881	35,313	78,011	10,014	7,530	216,749	1.09
1973	80,233	38,585	75,459	8,067	7,212	209,556	1.06
1974	76,129	35,387	73,509	5,463	6,933	197,421	1.03
1975	79,176	33,512	64,856	272	4,985	182,781	1.06

[1] Does not include extraction loss, lease and plant fuel, and pipeline fuel after 1966.

SOURCE: U.S. Bureau of Mines, Mineral Industry Survey; Natural Gas Production and Consumption, 1966-1975: U.S. Bureau of Mines, Minerals Yearbook, 1950-1965.

TABLE 5.2.2

KENTUCKY AND U.S. MARKETED PRODUCTION[1] OF NATURAL GAS, 1947-1975
(Million Cubic Feet

Year	Kentucky	U.S.
1947	96,459	4,582,173
1948	70,095	5,148,020
1949	51,851	5,419,736
1950	73,316	6,282,060
1951	76,097	7,457,359
1952	73,427	8,013,457
1953	71,405	8,396,916
1954	72,713	8,742,546
1955	73,214	9,405,351
1956	73,687	10,081,923
1957	70,024	10,680,258
1958	72,248	11,030,298
1959	73,504	12,046,115
1960	75,329	12,771,038
1961	70,937	13,254,025
1962	70,241	13,876,622
1963	74,634	14,746,663
1964	76,940	15,462,143
1965	78,976	16,039,753
1966	76,536	17,206,628
1967	89,168	18,171,325
1968	89,024	19,322,400
1969	81,304	20,698,240
1970	77,892	21,920,642
1971	72,723	22,493,012
1972	63,648	22,531,698
1973	62,396	22,647,549
1974	71,876	21,600,522
1975	60,511	20,108,661

[1]Marketed production of natural gas represents gross withdrawals less gas used for repressuring and quantities vented and flared.

SOURCE: U.S. Bureau of Mines; Natural Gas Annuals; and Mineral Industry Surveys: Natural Gas, 1974-1975.

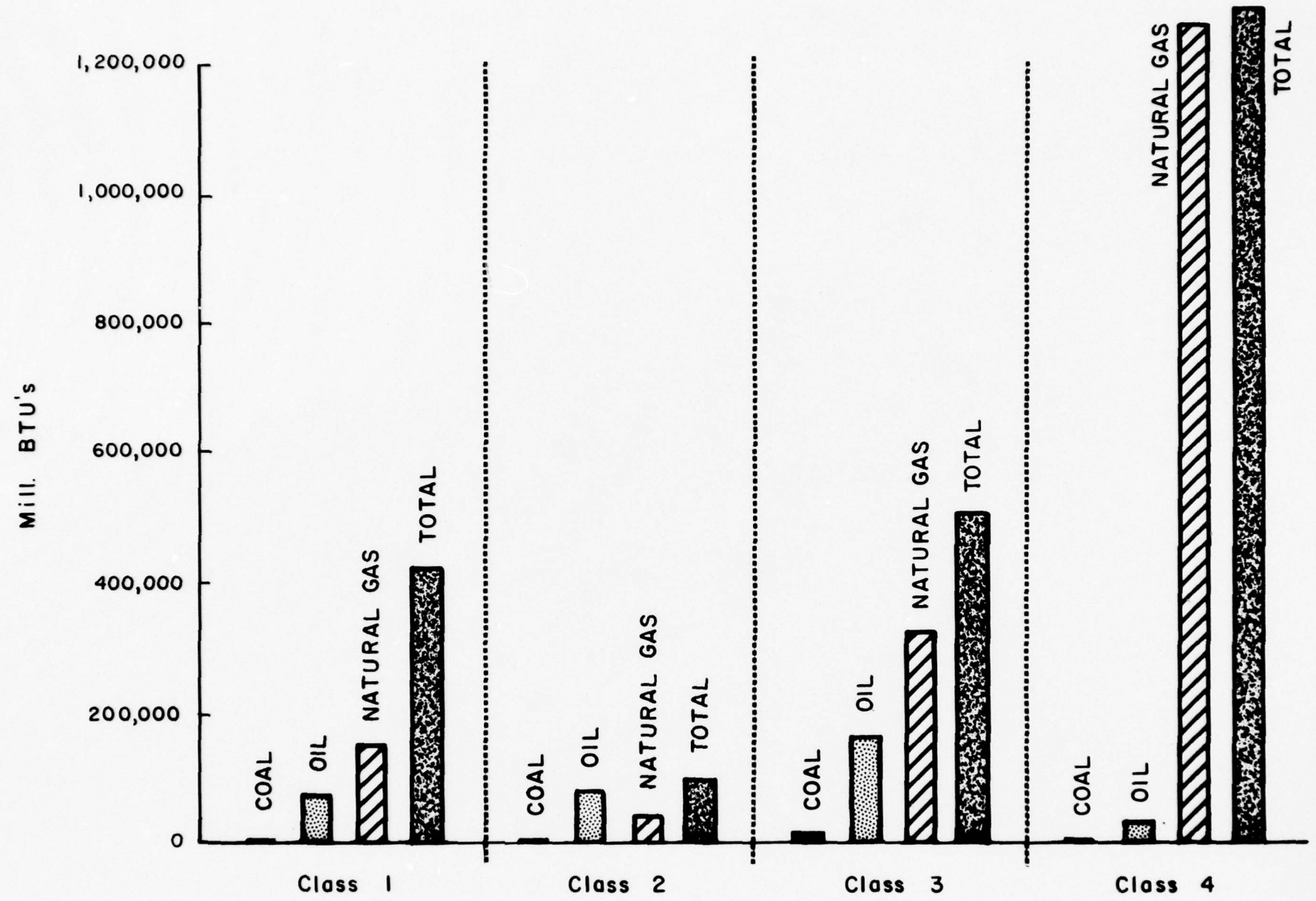

Fig. 5.2.1 : Fort Knox Energy Input or Production For Class I Through Class 4 Boiler & Heating Plants For Fiscal Year 1976. (Data Obtained From DA Form 2788)

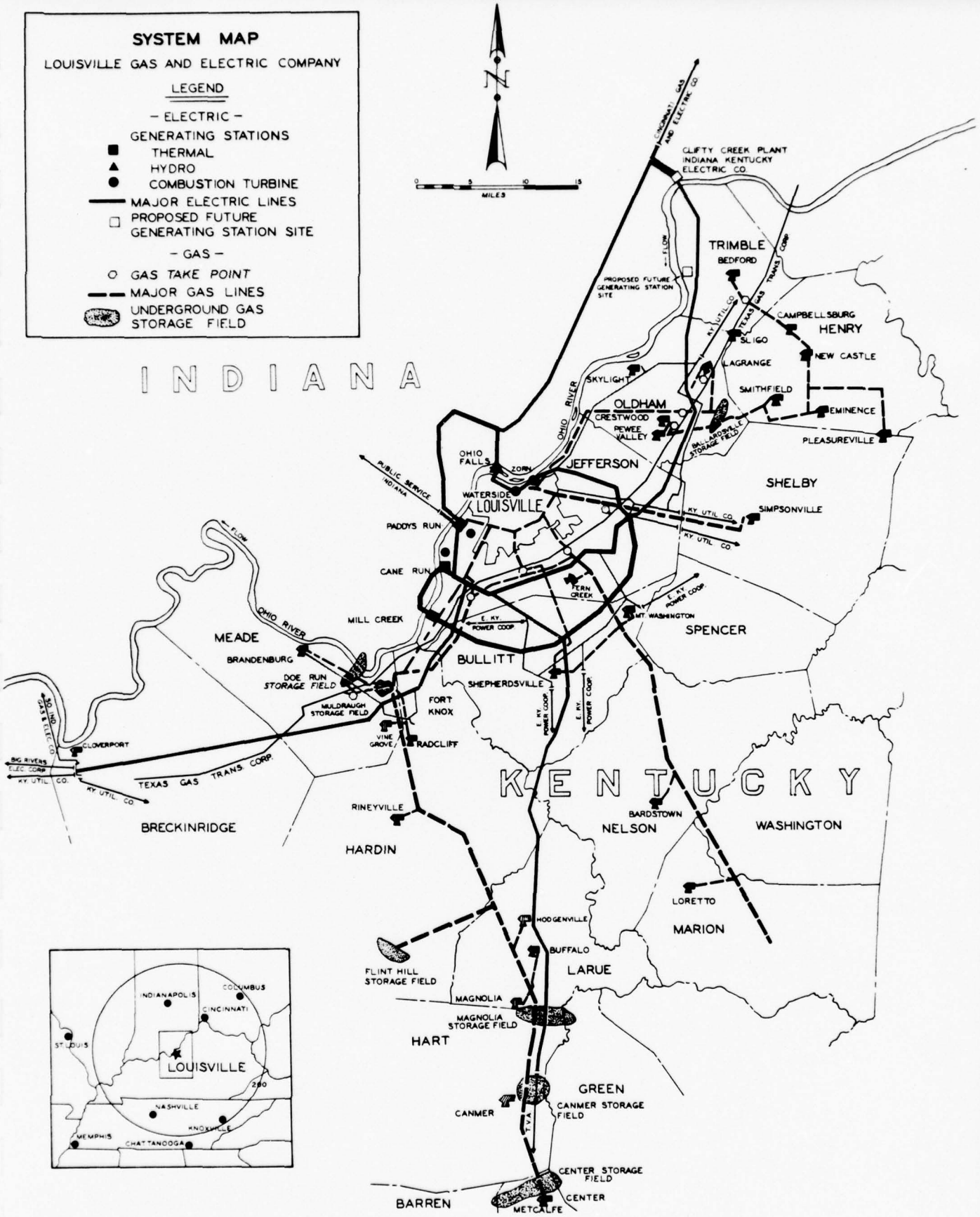

FIGURE 5.2.2 LOUISVILLE GAS & ELECTRIC COMPANY SERVICE AREA

The Louisville Gas and Electric Co. purchases all of its natural gas from Texas Gas Transmission Corporation (Texas Gas) at rates and terms regulated by the FPC. The present purchase contract, expiring in 1988, provides for a maximum daily delivery of 239,706 thousand cubic feet (MCF) at 14.73 psia. At a 100% load factor, annual delivery under this contract would be 87,492,690 MCF.

5.2.4 Regulation and Rates

The Fort Knox gas rate presented in Table 5.2.3 is negotiated between Louisville Gas and Electric and Fort Knox subject to the following regulations established by the Kentucky Commission having regulatory jurisdiction over the rates and service of Louisville Gas and Electric. Louisville Gas and Electric is a "public utility" as defined in the Federal Power Act and is subject to the jurisdiction of the Federal Power Commission (FPC) with respect to matters covered in such Act, including the sale of electric energy at wholesale in interstate commerce.

The Louisville Gas and Electric plans to file for a rate increase in December 1976, which would allow billing increases, subject to refund, in the second quarter of 1977. Under Kentucky law, the Kentucky Commission must issue an order regarding the requested increase within ten months after the application is filed. The extent of the increase to be requested has not been determined.

The gas rate schedules of the Company contain a purchased gas adjustment provision, whereby increases and decreases in the rates charged to Louisville Gas and Electric by its gas supplier may be reflected in its rates, subject to approval of the Kentucky Commission. This provision has been in effect since 1957 and the Kentucky Commission has regularly authorized increases and decreases in the Company's gas rates commensurate with changes in rates paid for gas purchased.

TABLE 5.2.3

LOUISVILLE GAS AND ELECTRIC COMPANY

FORT KNOX GAS RATE

Effective August 20, 1975

Rate:

Demand Charge:
$1.45 net per month per Mcf of billing demand.

Commodity Charge:
70.5 cents net per Mcf delivered.

Purchased Gas Adjustment:
To each bill computed at the above charges shall be added an amount computed at the Purchased Gas Adjustment lawfully in effect with respect to the period covered by such bill, and duly set forth in Company's gas tariff as filed with the Public Service Commission of Kentucky.

Minimum Charge:
The monthly bill shall in no event be less than the demand charge computed upon the billing demand for the month.

Determination of Billing Demand:
The billing demand for the month shall be the maximum daily demand as measured by the consumption in Mcf on the day when the consumption is greater than on any other day of the month, for this purpose the term day being considered to mean the 24-hour period between 8:00 A.M. of one day and 8:00 A.M. of the following day. *Provided, however, that the billing demand for any month* shall not be taken as less than the maximum daily demand similarly determined during the eleven preceding months, nor less than 11,000 Mcf.

Billing Period:
The billing period for gas supplied hereunder shall be the calendar month.

Delivery and Metering:
Delivery of gas hereunder may be made at more than one point with separate metering at each point, meter readings being combined for billing hereunder both as to demand and commodity charges. For demand purposes meter readings at each of the separate points will be as near to 8:00 A.M. as reasonably feasible. Meters at the separate points will be read in the same sequence each time they are read, in accordance with a schedule to be agreed upon between Customer and Company. So long as such schedule is adhered to, all meter readings will be taken as though read at 8:00 A.M.

If for any reason a significant variation from the schedule is experienced, appropriate adjustment of the metered quantity shall be made for billing purposes. The Company shall not be required to make daily meter readings during the summer months or at other times when the daily consumption of gas obviously would not affect the billing demand for any month.

Applicability of Rules:

Service under this rate schedule is subject to Company's rules and regulations governing the supply of gas service as incorporated in its Tariff as filed with the Public Service Commission of Kentucky.

Regulatory Jurisdiction:

Rates, terms, and conditions herein provided are subject to the regulatory jurisdiction of the Public Service Commission of Kentucky.

On September 27, 1976, in accordance with FPC orders prescribing new nationwide gas rates, Texas Gas made a special rate filing increasing Louisville Gas & Electric's purchased gas costs by approximately 23.8¢ per Mcf, effective October 27, 1976. On September 30, 1976, Louisville Gas and Electric filed with the Kentucky Commission, pursuant to the Purchased Gas Adjustment Clause contained in its tariff, an application for an increase in its rates sufficient to recoup the increase in its purchased gas cost. Louisville Gas and Electric anticipates that there will be no adverse effect on its gas operations resulting from the higher nationwide rates allowed by FPC.

5.3 Propane

5.3.1 Discussion

LP gas provides only 0.27% of the total energy requirements of Ft. Knox and is utilized only as part of the post recreation program. No change in the status of LP gas usage is anticipated in the future. The annual cost of this energy source in the past has been approximately $3,000. Due to LP's rather insignificant utilization at Ft. Knox, and no anticipated change in the coming years, it's impact will be minimal; consequently, there will be no further discussion of propane.

5.4 Electricity

5.4.1 Supplier

The Louisville Gas and Electric Company supplies electric service in Louisville and vicinity including the Ft. Knox area. The Louisville Gas and Electric service area covers approximately 700 square miles with an estimated population of 800,000, exclusive of Ft. Knox. The utility industry, as a whole, is faced with a number of financial and operational difficulties, including the need for large expenditures for air and water pollution abatement programs, high costs of raising capital, continuously rising construction costs, curtailment of gas supply, and the adverse impact of conservation programs on the electrical power and gas sales. Louisville Gas and Electric too, has been hit by certain of these problems in varying degrees. However, Louisville Gas and Electric considers that "its own experience and outlook to these difficulties have been favorable".

5.4.2 Consumption

From 1972 until 1974, the Fort Knox electrical consumption was on a downward trend (See Table 5.4.1 and Figure 4.2.3). No large scale demolition took place on the installation to cause the apparent decrease in electrical consumption during this period. This reduction in consumption is perhaps attributable to the conservation measures put into effect following the November 1973 oil embargo. The electrical power usage increased from 1974 to 1975 and incomplete data indicates a further increase in 1976 but there has not yet been a return to the pre-embargo consumption.

Among the conservation measures in effect to reduce electrical power consumption is the present air conditioning policy at Fort Knox. This policy prohibits the use of air conditioning until the outside air temperature reaches a minimum of 80° F. Additionally, air conditioning is not permitted after 1500 hours.

TABLE 5.4.1

FORT KNOX HISTORICAL CONSUMPTION - ELECTRICITY

YEAR	CONSUMPTION MILL. KWH	CHANGE OVER BASE (%)	CHANGE OVER PREVIOUS YEAR (%)
1972	140.386	BASE	--
1973	136.150	-3	-3
1974	115.198	-18	-15
1975	129.692	-8	+13

In recent years, electric power consumption has reflected the increased usage of compression refrigeration air conditioning systems. During this time, the Department of Defense has liberalized requirements which authorize air conditioning in military facilities. Air conditioning, where authorized, is normally not optional, but is required. In an effort to reduce the impact of this policy, DOD has required better insulated facilities with more efficient heat transfer coefficients ("U" factors) to reduce both heating and cooling requirements.

Air conditioning loads for new construction can be estimated accurately and these loads should be included in feasibility studies and cost analyses which affect the Fort Knox energy plan. As these loads may unfavorably impact the energy plan, consideration must be given to oil-fired absorption air conditioning systems in lieu of the electric driven type.

5.4.3 Demand

The highest electrical demands at Fort Knox have historically occurred during the months of July and August. This is to be expected for an installation in a geographic location such as Fort Knox's. These demands result from the heavy use of electric air conditioning equipment during the summer months. In the period from 1965 to 1975, Louisville Gas and Electric Co.'s peaks, too, occurred exclusively in July and August, except in 1967 when their peak occurred on June 15th. Fort Knox's historical power demand is summarized in Table 5.4.2. As can be seen from this table, the 1974 peak demand is the lowest for the four-year period with a 12% decrease from the base demand. As with the electrical consumption, this decrease in power demand perhaps stemmed from the conservation measures imposed as a result of the 1973 oil embargo.

5.4.4 Total Consumption and Demand in the Service Area of Supplier

Between 1965 and 1973, Louisville Gas and Electric Co.'s annual

TABLE 5.4.2

FORT KNOX HISTORICAL DEMAND - ELECTRICITY

YEAR	MONTH	PEAK DEMAND (KW)	CHANGE OVER BASE (%)	CHANGE OVER PREVIOUS YEAR (%)
1972	July	30,900	Base	--
1973	July & Aug.	31,500	+2	+2
1974	July	27,300	-12	-13
1975	August	30,600	-1	+12

electrical sales (KWHs) grew at a compound growth rate of 7%. These growth rates were in line with the national growth trends. In 1974, electrical sales (KWHs) fell by 5.5% from the previous year. During the same period, 1965 through 1973, demand peaks grew at a compound rate of 10% with a 12% decrease from 1973 to 1974. Demand peak showed a slight increase from 1974 to 1975. These decreases in sales and demand from 1973 to 1974 are, once again, directly attributable to conservation measures imposed following the 1973 Arab oil embargo. Table 5.4.3 provides a historical summary of Louisville Gas and Electric Co.'s peak demands and annual KWH sales over a period from 1965 to 1975.

5.4.5 Generation and Distribution

Louisville Gas and Electric Co.'s service area indicating major electric lines and the location of their thermal, hydro and combustion turbine generating stations is shown in Figure 5.2.2. Table 5.4.4 is a breakdown in percentages of Louisville Gas and Electric Co. generated by primary source of energy (percent of kilowatt-hour output). As evidenced from the data in Table 5.4.4 no oil is used for power generation; consequently, Louisville Gas and Electric Co. is free of any direct effects of imported oil prices but could be adversely affected by lengthy transportation or mine workers strikes.

5.4.6 Fort Knox's Effect on Louisville Gas and Electric Co. and the State of Kentucky

Fort Knox represents approximately 1.8% of Louisville Gas and Electric Co.'s market, but only 0.27% of the electrical sales within the State of Kentucky. (See Tables 5.4.5 and 5.4.6.) Tables 5.4.7, 5.4.8 and 5.4.9 are included to indicate the electric industry characteristics of the State of Kentucky.

5.4.7 Rate Structure

Table 5.4.10 indicates the present electric rate for Fort Knox.

TABLE 5.4.3

HISTORICAL LG&E SUMMARY - ELECTRICITY

YEAR	PEAK(MW)	CAPACITY (MW)	ACTUAL RESERVE AT TIME OF PEAK (%)	SALES (BILLION KWH)
1965	823	990	17%	4.423
1966	1166	1242	6%	5.070
1967	1117	1264	12%	5.122
1968	1236	1372	10%	5.814
1969	1466	1685	13%	6.673
1970	1485	1668	11%	7.055
1971	1271	1617	21%	6.909
1972	1674	1976	15%	7.074
1973	1736	1960	11%	7.600
1974	1523	2213	31%	7.178
1975	1543	2189	29%	7.320

TABLE 5.4.4

SUMMARY OF LG&E POWER PRODUCTION

PRIMARY SOURCE OF ENERGY	PERCENT OF KILOWATT-HOUR OUTPUT DURING				
	1973	1974	1975	12 MOS. ENDED 10/31/76	PROPOSED 1977
COAL	78%	81%	91%	95%	94%
GAS	9	7	--	--	--
HYDRO	5	5	5	6	5
PURCHASED & INTERCHANGED (NET)	8	7	4	(1)	1
TOTAL	100%	100%	100%	100%	100%

TABLE 5.4.5

COMPARISON OF ELECTRICAL POWER CONSUMPTION AND DEMAND
AT FT. KNOX AND TOTAL LG&E SERVICE AREA

	CONSUMPTION			DEMAND		
YEAR	FT. KNOX KWH x 10^6	LG&E KWH x 10^6	% OF LG&E	FT. KNOX MW	LG&E MW	% OF LG&E
1972	140.386	7074.993	1.9%	30.9	1674	1.8%
1973	136.150	7600.909	1.8%	31.5	1736	1.8%
1974	115.198	7178.725	1.6%	27.3	1523	1.8%
1975	129.692	7320.761	1.7%	30.6	1543	2.0%

TABLE 5.4.6

ELECTRICITY SALES IN KENTUCKY--TOTAL ELECTRIC UTILITY INDUSTRY, BY YEARS AND CLASSES OF SERVICE
(Kilowatt-Hours in Millions)

Year	Total	Residential	Commercial and Industrial		Other[1]
			Small Light and Power	Large Light and Power	
1957	27,378	2,271	1,003	23,733	371
1958	25,836	2,495	1,089	21,862	390
1959	27,319	2,721	1,202	22,965	431
1960	28,651	2,965	1,145	24,081	460
1961	28,709	3,049	1,330	23,802	528
1962	28,493	3,389	1,478	23,027	599
1963	29,586	3,689	1,634	23,625	638
1964	29,237	4,079	1,792	22,717	649
1965	28,388	4,188	1,996	21,501	703
1966	28,444	4,478	2,117	21,052	797
1967	28,691	4,866	2,322	20,648	855
1968	30,822	5,810	2,622	21,456	934
1969	30,942	6,143	2,923	20,859	1,017
1970	32,108	7,148	3,285	20,540	1,135
1971	36,283	8,680	4,288	22,109	1,206
1972	39,313	9,047	4,533	24,439	1,294
1973	43,597	9,386	7,435	25,387	1,389
1974	43,526	9,433	7,540	25,192	1,361
1975	46,824	10,098	8,730	26,520	1,476

[1]Street and highway lighting, sales to public authorities, interdepartmental sales, and sales to railroads and railways.

SOURCE: Edison Electric Institute, Statistical Yearbook, 1957-1974.

NOTE: This table includes electricity usage by Paducah Gaseous Diffusion Plant which significantly distorts the trends. (In the "Large Light and Power" column. Compare with "Industrial" in attached table.)

TABLE 5.4.7

KENTUCKY INSTALLED GENERATING CAPACITY--
TOTAL ELECTRIC UTILITY INDUSTRY, 1952-1975
(Kilowatts in thousands - name plate)

Year	Hydro	Conventional Steam	Internal Combustion	Conventional Steam as % of Kentucky Total	Kentucky Total	U. S. Total
1952	541	718	6	56.8	1,265	82,226
1953	541	1,179	7	67.9	1,727	91,502
1954	541	1,919	8	77.8	2,468	102,592
1955	541	2,196	8	80.0	2,745	114,472
1956	541	2,428	8	81.6	2,977	120,697
1957	541	2,587	9	82.5	3,137	129,123
1958	541	2,700	8	83.1	3,249	142,597
1959	541	2,751	8	83.4	3,300	156,841
1960	541	2,813	8	83.7	3,362	168,002
1961	541	2,833	8	83.8	3,382	180,668
1962	541	2,914	8	84.1	3,463	191,067
1963	540	5,128	8	90.3	5,676	210,549
1964	541	5,293	8	90.6	5,842	222,285
1965	541	5,543	8	91.0	6,092	236,127
1966	671	5,908	8	89.7	6,587	247,843
1967	671	5,908	8	89.7	6,587	269,252
1968	671	6,002	8	89.8	6,681	291,058
1969	676	7,277	8	91.4	7,961	313,349
1970	681	8,649	8	92.6	9,338	341,090
1971	686	9,250	8	93.0	9,944	367,396
1972	686	9,654	8	93.3	10,348	399,606
1973	686	10,051	8	93.5	10,745	439,875
1974r	685	11,347	13	94.2	12,045	476,168
1975p	685	11,363	13	94.2	12,061	502,245

r Revised.
p Preliminary

SOURCE: Edison Electric Institute, Statistical Yearbook, 1952-1975, from Federal Power Commission Data.

TABLE 5.4.8

ELECTRICITY GENERATED IN KENTUCKY BY TYPE OF PRIME MOVER DRIVING THE GENERATOR, 1952-1975[1]
(Kilowatt-hours in Millions)

Year	Hydro	Conventional Steam	Internal Combustion	Nuclear	Conventional Steam as % of Total	Total
1952	2,129	3,999	10	--	65.2	6,138
1953	2,193	6,238	11	--	73.9	8,442
1954	2,087	10,468	11	--	83.3	12,566
1955	2,550	15,130	13	--	85.5	17,693
1956	2,491	15,573	11	--	86.2	18,075
1957	2,727	16,177	12	--	85.5	18,916
1958	2,829	16,115	12	--	85.0	18,956
1959	2,271	16,828	12	--	88.1	19,111
1960[a]	2,633	17,252	14	--	86.7	19,899
1961[a]	2,545	17,411	14	--	87.2	19,970
1962[a]	2,775	17,859	14	--	86.5	20,648
1963[a]	2,328	23,455	15	--	90.4	25,798
1964[a]	2,414	27,238	15	--	91.8	29,667
1965[a]	2,464	29,112	16	--	92.1	31,592
1966[a]	2,565	29,320	17	--	91.9	31,902
1967[a]	3,697	31,129	14	--	89.3	34,840
1968[a]	2,926	32,206	1	--	91.7	35,133
1969	2,678	35,560	--	--	93.0	38,238
1970	3,174	41,946	--	--	93.0	45,120
1971	3,536	45,753	--	--	92.8	49,289
1972	3,819	49,891	--	--	92.9	53,710
1973	3,823	49,126	--	--	92.8	52,949
1974	3,398	50,147	--	--	93.7	53,545
1975[P]	3,464	47,645	--	--	93.2	51,109

[1]For the total electric utility industry.

[P]Preliminary

[r]Revised

[a]Not including industrial plants contributing to the public supply and imports.

SOURCE: Edison Electric Institute, Statistical Yearbook, 1952-1975.

TABLE 5.4.9

ADJUSTED ELECTRICITY SALES IN KENTUCKY*
(In Millions of Kilowatt-Hours)

Year	Residential	Commercial	Industrial*	Other**	Total*
1957	2,271	1,003	4,868	371	8,513
1958	2,495	1,089	4,504	390	8,478
1959	2,721	1,202	4,988	431	9,342
1960	2,965	1,145	5,385	460	9,955
1961	3,049	1,330	5,583	528	10,490
1962	3,389	1,478	6,067	599	11,533
1963	3,689	1,634	6,640	638	12,601
1964	4,079	1,792	7,386	649	13,906
1965	4,188	1,996	7,829	703	14,716
1966	4,478	2,117	8,839	797	16,231
1967	4,866	2,322	9,832	855	17,875
1968	5,810	2,622	10,726	934	20,092
1969	6,143	2,923	11,211	1,017	21,294
1970	7,148	3,285	11,597	1,135	23,165
1971	8,680	4,288	11,505	1,206	25,679
1972	9,047	4,533	12,546	1,294	27,420
1973	9,386	7,435	12,713	1,389	30,923
1974	9,433	7,540	12,739	1,361	31,073

*Excludes electricity used by Paducah Gaseous Diffusion Plant.

**Street and highway lighting, sales to public authorities, interdepartmental sales, and sales to railroads and railways.

SOURCE: Edison Electric Institute, Statistical Yearbook, 1957-1974 and Energy Research and Development Administration, Power Branch, Oak Ridge, Tennessee, July 29, 1976.

TABLE 5.4.10

LOUISVILLE GAS AND ELECTRIC COMPANY

FORT KNOX ELECTRIC RATE

Effective August 20, 1975

Availability:

Available for electric service as hereinafter described to the Fort Knox Military Reservation. This rate schedule does not apply to the separately-served Muldraugh Pumping Plant.

Rate:

Demand Charge:

First 2,000	kilowatts of billing demand	$2.00 per kilowatt per month
Excess	kilowatts of billing demand	$1.75 per kilowatt per month

Energy Charge:

First 1,000,000	kilowatt-hours per month	.90¢ per kilowatt-hour
Excess	kilowatt-hours per month	.78¢ per kilowatt-hour

Determination of Billing Demand:

The billing demand for the month shall be the highest average load in kilowatts occuring during any 15-minute interval in the month as shown by maximum demand instrument, but not less than 50% of the maximum demand similarly delivered during the eleven preceding months, nor less than a minimum billing demand of 5,000 kilowatts.

Load Factor Discount:

A discount of 1.435 mills (.1425¢) per kilowatt-hour will be allowed on that portion of the monthly kilowatt-hour consumption in excess of 360 hours use of the billing demand for such month.

Power Factor Discount:

The monthly amount computed in accordance with the provisions set forth above shall be decreased .2% for each whole one percent by which the monthly average power factor exceeds 80% lagging and shall be increased .3% for each whole one percent by which the monthly average power factor is less than 80% lagging.

Fuel Clause:

The monthly amount computed in accordance with the provisions set forth above shall be increased or decreased at the rate of .103 mill (.0103¢) per kilowatt-hour of monthly consumption for each one cent per million Btu by which the average cost of fuel consumed during the preceding month is more or less respectively than 33.8¢ per million Btu. The average cost of fuel consumed during any month is that cost determined by dividing the total charges to the Fuel expense accounts during such month by the number of millions of Btu Consumed;

provided, however, that such average cost will be reduced to the extent that fuel purchased at higher than average cost is consumed in the production of energy for sale to other electric utilities companies.

The increase or decrease shall be made in direct proportion to the difference from the base fuel cost of 33.8¢ per million Btu, including differences of fractional parts of a cent.

The determination of average cost of fuel for any month shall be based on actual determinants to the extent practicable and on estimates where necessary to effect a timely calculation. To the extent that such estimates differ from actual amounts as subsequently determined, the calculation for the next month shall reflect a correction of such deviations.

Minimum Monthly Charge:

The monthly bill shall in no event be less than the demand charge computed upon the billing demand for the month.

Billing Period:

The billing period for electric service hereunder shall be the calendar month.

Delivery and Metering:

Service hereunder shall be metered at 34,500 volts at Company's 138/34.5 Kv Tip Top Substation, jthen transmitted and delivered at 34.5 Kv by Company over two circuits to Customer's several substations. Meter readings on Company's two circuits will be combined for billing and the maximum demand will be determined as the coincident maximum demand on such two circuits.

Applicability of Rules:

Service under this rate schedule is subject to Company's rules and regulations governing the supply of electric service as incorporated in its Tariff as filed with the Public Service Commission of Kentucky.

Regulatory Jurisdiction:

Rates, terms, and conditions herein provided are subject to the regulatory jurisdiction of the Public Service Commission of Kentucky.

LOUISVILLE GAS AND ELECTRIC COMPANY
Louisville, Kentucky 40201

PSC of Ky. Electric No. 3

FUEL CLAUSE ADJUSTMENT

Effective - November, 1976

Applicable to Rates R, WH, GS, DC, SLE, TLE, LC and LP	.30080¢ per Kwh charge

Cost of fuel per million Btu - October, 1976	63.0034¢
Base Cost per million Btu	33.8¢
Cost per million Btu over Base Cost	29.2034¢

Conversion to Fuel Clause Adjustment per kwh:

29.2034 X .0103¢ per Kwh = .30080¢ per Kwh

Date of Issue November 1, 1976

Issued by W. B. Thurman
Vice President

5.5 Coal

5.5.1 General

Coal is the United States' most abundant domestic energy resource. At current consumption levels, the U. S. has enough coal reserves to last at least 300 years. At projected 1985 consumption levels, the U. S. has enough reserves to last at least 200 years. The above statements are conclusions of the Federal Energy Administration as published in the 1976 "National Energy Outlook".

As indicated in Table 5.5.1, Kentucky lies in the area of the U. S. that in 1972 produced the largest tonnage of coal in the U. S. Kentucky is also normally the second largest producer of bituminous coal in the U. S.

5.5.2 Consumption

Presently, coal represents only 0.63% of Ft. Knox's total energy requirements, with approximately 1120 tons consumed annually. Coal is used exclusively for comfort heating in class 3 and 4 heating plants. Tables 5.5.2 and 5.5.3 indicate the state of Kentucky's consumption and production. Refer to Figure 4.2.1 for fiscal year 1976 Fort Knox coal consumption in million Btu's and Figure 5.1.1 for Fort Knox yearly coal consumption comparisions in tons for fiscal years 1975 and 1976 and target consumption for FY 1977.

5.5.3 Costs

Figure 4.2.8 indicated that in fiscal year 1976 Fort Knox paid $0.76 per million Btu's for its coal. Table 5.5.4 is a listing of historical coal prices from April 1973 to August 1975. Table 5.5.5 indicates a U. S. energy cost projection. These projections were obtained from a presentation to the manufacturing committee of the American Boiler Manufacturers Association by Mr. Robert W. Exline on June 9, 1976. This projection shows coal increasing in dollars/million Btu's, by 1990 by a factor of 2.49, with natural gas

TABLE 5.5.1

COAL PRODUCTION BY REGION AND MINING METHOD, 1945-72

YEAR		Appalachia*			Interior**			Far West***			National		
		Surface	Deep	Total	Surface	Deep	Total	Surface	Deep	Total	Surface	Deep	Total
1972	Million Tons	144.6	242.6	387.2	105.2	52.1	157.3	41.3	9.3	50.6	291.1	304.0	595.1
	Percent	37	63	100	67	33	100	82	18	100	49	51	100
1970	Million Tons	143.0	274.8	417.8	95.6	54.3	149.9	25.2	9.6	34.9	263.9	338.7	602.6
	Percent	34	66	100	64	36	100	72	28	100	44	56	100
1965	Million Tons	89.8	295.1	384.9	78.4	28.5	106.9	11.1	9.2	20.3	179.3	332.8	512.1
	Percent	23	77	100	73	27	100	55	45	100	35	65	100
1955	Million Tons	78.5	297.3	375.8	36.5	33.8	70.3	6.2	12.3	18.5	121.2	343.4	464.6
	Percent	21	79	100	52	48	100	34	66	100	26	74	100
1945	Million Tons	64.7	366.1	430.8	39.8	72.7	112.5	5.7	28.9	34.6	110.2	467.7	577.9
	Percent	15	85	100	35	65	100	16	84	100	19	81	100

* Alabama, Georgia, Kentucky (Eastern), Msryland, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia
** Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky (Western), Michigan, Missouri, Oklahoma
*** Alaska, Arizona, Colorado, Montana, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming.

Source: Bureau of Mines

TABLE 5.5.2

Kentucky and U.S. Coal[a] Production, 1950-1975
(Short Tons)

Year	Kentucky[1]	U.S.[2]	Ky. as % of U.S.
1950	82,176,693	516,311,053	15.9
1951	73,951,266	533,664,732	13.9
1952	64,515,091	466,840,782	13.8
1953	63,535,507	457,290,449	13.9
1954	58,621,115	391,706,300	15.0
1955	68,900,744	464,633,408	14.8
1956	75,934,180	500,874,077	15.2
1957	75,775,936	492,703,916	15.4
1958	67,809,271	410,445,547	16.5
1959	64,990,298	412,027,502	15.8
1960	67,067,740	415,512,347	16.1
1961	65,395,255	402,976,802	16.2
1962	70,049,475	422,149,325	16.6
1963	78,139,040	458,928,175	17.0
1964	83,283,504	486,997,952	17.1
1965	87,216,039	512,088,263	17.0
1966	93,239,875	533,881,210	17.4
1967	100,106,241	522,626,000	19.2
1968	100,975,868	545,245,000	18.5
1969	108,045,470	560,505,000	19.3
1970	125,308,395	602,932,000	20.8
1971	119,167,582	552,192,000	21.6
1972	120,271,247	595,386,000	20.2
1973	127,507,320	591,738,000	21.6
1974	136,768,549	603,406,000	22.8
1975	144,204,511	639,280,000	22.6

a. Bituminous and lignite.

SOURCE: [1]Kentucky Department of Mines and Minerals, Annual Report, 1950-1975.

[2]U.S. Bureau of Mines; Federal Energy Administration, Monthly Energy Review.

TABLE 5.5.3

KENTUCKY COAL UTILIZATION BY SECTOR, 1968-1975
(Thousand Short Tons)

Sector	1968	1969	1970	1971	1972	1973	1974	1975
Electric Utilities	14,094	15,696	19,108	21,611	23,460	21,734	21,710	25,724
Coke & Gas Plants	1,831	1,827	1,591	1,660	1,631	1,162	1,397	1,241
Retail Dealers	560	540	602	341	319	314	267	187
All Others[1]	2,326	2,292	2,371	1,978	1,979	1,868	2,071	1,328
Total	18,811	20,355	23,672	25,590	27,389	25,078	24,445	28,480

[1]Excludes vessel fuel and bunker fuel, the destinations of which are not available.

SOURCE: U.S. Bureau of Mines, Minerals Yearbook, 1968-1973; U.S. Bureau of Mines, Bituminous Coal and Lignite Distribution, 1974, 1975.

REVISED: 10/76

TABLE 5.5.4

NATIONAL AVERAGE PRICES OF DELIVERED COAL AND
RESIDUAL OIL TO ELECTRIC UTILITIES
($/Million Btu, Current Dollars)

	Coal		Residual Oil (No. 6)
	Average Spot Price	Average Contract Price	Average Contract Price
April 1973	.44	.38	.68
July 1973	.44	.39	.71
October 1973	.48	.40	.87
January 1974	.76	.45	1.54
April 1974	1.04	.52	1.86
July 1974	1.25	.56	1.95
October 1974	1.39	.62	2.00
November 1974*	1.47	.67	2.00
January 1975	1.26	.68	1.98
April 1975	1.08	.74	2.12
July 1975	.98	.76	2.00
August 1975**	.98	.78	2.02

* Spot coal prices reached their peak.
** Last month for which data is available.

TABLE 5.5.5

UNITED STATES ENERGY COST PROJECTION

SOURCE	YEAR			
	1975	1980	1985	1990
Natural Gas				
$/Mcf	1.00	2.75	4.50	7.50
$/MMBTU	1.00	2.75	4.50	7.50
Electricity				
¢/KWH	2.00	3.00	3.50	4.25
$/MMBTU	5.86	8.79	10.26	12.45
Petroleum				
$/Bbl.	12.00	17.00	22.00	30.00
$/MMBTU	2.04	2.89	3.74	5.10
Coal				
$/Ton	30.00	40.00	55.00	75.00
$/MMBTU	1.25	1.66	2.29	3.12

Mcf - 1000 cubic feet

MMBTU - 10^6 BTU

increasing by 7.5, electricity by 7.5 and petroleum by a factor of 2.5. Mr. Exlines' projections indicate that coal will continue to be the cheapest energy source in 1990.

5.5.4 Conversion to Coal

Due to several practical reasons, rapid substitution of coal for oil or natural gas is difficult. These factors include but are not limited to the physical constraints; i.e., lack of boilers that could burn coal, coal and ash handling facilities, and pollution control equipment. Coal supply is also an important constraint in that while coal is demand-constrained in the long run, it can be supply-constrained in the short run, since it takes 4 to 7 years to open a large new mine and the capacity of the industry to increase production rapidly is limited. The capital costs of converting existing boilers to coal and installing pollution control equipment may be so high that it is cheaper for a user, Ft. Knox, all costs considered to continue to burn oil or gas. Decisions on utilization of coal as the primary energy source for the post can only be substantiated by a feasibility study applying directly to Fort Knox. These same constraints, once again apply to rapid conversion to coal. Conversion to coal at Fort Knox over a long period may remove some of these constraints, but only after an in-depth study of coal conversion at Ft. Knox could rapid conversion from other fuels to coal be recommended. Because of the seemingly large quantity of coal available to the U. S. and the large amount produced in Kentucky. Studies should be undertaken as indicated above.

5.5.5 Supply and Availability

Coal is obtained at Ft. Knox through the U. S. Army Material and Petroleum Activity. Refer to Section 5.1.3 for an explanation of the procurement process. As indicated in Section 5.5.1, coal represents the

largest energy resource in the U. S. and a large percentage of the available coal reserves lie within the boundaries of the state of Kentucky. Therefore, the availability of coal to Ft. Knox is only transportation-limited. Of course, mine workers strikes would affect the supply at Fort Knox. However, this problem could be alleviated by sufficient stockpiling of the commodity at the installation.

As of 10 November 1976, there were 1350 tons of coal stockpiled at Ft. Knox with an additional 350 tons requested. This 1350 ton stockpile of coal represents the equivalent of 1% of all the energy consumed by the post each year.

5.6 Solid Waste Incineration

Density of solid wastes produced at military installations varies significantly from base to base. Rigo* indicated the density ranging from a low 25 pounds per cubic yard to a high 327 pounds per cubic yard with an average value of 84 pounds per cubic yard. Heating value of the solid wastes depends upon its characteristics; for example, Type 0 has a caloric value of 8500 Btu/pound; Type 1, 6500 Btu/pound; Type 2, 4300 Btu/pound, etc. Generally residential buildings on military bases produces wastes with a heat generation value of about 500 Btu/pound and shops and commercial installations produce wastes with higher heating value of about 7000 Btu/pound. Since Fort Knox is comprised of an admixture of family housing, administration buildings, barracks and shops, the average heating values of the solid waste produced may be assumed to be about 6000 Btu/pound. The 60-ton per day refuse generated at Fort Knox, therefore, represents an equivalent energy content of 720×10^6 Btu/day. This is about 10% of the total natural gas and about 7% of all energy sources used at Fort Knox.

*Rigo, H. D., "Characteristics of Military Refuse." USA Construction Engineering Research Laboratory, Champaign, Ill.

6. ECONOMIC CONSIDERATIONS

6.1 General

Unit energy costs at Ft. Knox are greatly influnced by those prevailing in the United States as a whole. Since far more statistical information has been gathered for the entire country during the post oil embargo era, discussion of the energy costs relative to the nation is more meaningful. Such data, though not directly applicable to Ft. Knox, can be easily related to the installation.

Before economic aspects can be discussed, an overview of the future outlook for energy supplies as to their source and dependability is in order. Tables 6.1 and 6.2 show a short-term and a long-term projection of energy demand and supply for the United States. Alaskan gas pipeline estimated to cost $10 billion will supply only supplemental quantities of natural gas, and, that too sometime after 1983. Coal gasification has some promise but environmental and regulatory problems still exist. Imported liquefied natural gas from the OPEC nations will cost upwards of $3 per thousand cubic foot in contrast to natural gas prices prevailing today of $1 per thousand cubic foot.

Alaskan oil and off-shore oil will contribute to the oil supply in the future. Not only is the oil from shale expensive, ($18 to $20 per barrel) methods of extracting it are environmentally unacceptable at the present time. Coal represents the most abundant energy resource in America. However, environmental considerations, mining and transportation problems due to lack of railroad capacity are causes for the less-than-optimum use of this resource.

Nuclear development has been slowed by environmental and safety regulations. Other energy sources such as hydroelectric, geothermal and wind, etc. will not contribute significantly within the coming few years.

TABLE 6.1

FIVE YEAR PROJECTION
OF
ENERGY SUPPLY AND DEMAND
FOR THE UNITED STATES

(MILLION BARRELS PER DAY OF OIL EQUIVALENT)

	YEAR					
	1976	1977	1978	1979	1980	1981
DEMAND	37.4	38.5	39.6	40.8	42.0	43.2
SUPPLY SOURCE						
Domestic Crude Oil Including Alaska	8.2	7.9	8.8	8.5	8.2	7.9
Natural Gas Including SNG, Canadian Gas & Imported LNG	9.5	9.0	8.6	8.3	8.0	7.7
Coal	7.5	7.6	7.8	8.0	8.2	8.4
Gas Liquids	1.7	1.7	1.7	1.7	1.7	1.7
Other Sources - Primarily Hydro-Electric & Nuclear	3.0	3.4	4.0	4.6	5.2	6.0
Imported Oil	7.5	8.9	8.7	9.7	10.7	11.5
TOTAL SUPPLY	37.4	38.5	39.6	40.8	42.0	43.2

TABLE 6.2

U. S. ENERGY PROJECTION UNTIL 2000

SOURCE	YEAR		
	1976	1985	2000
Energy consumption, quadrillion BTU's	71	104	164
Coal, % share	19	21	17
Petroleum, % share	46.6	44	31
Natural gas, % share	28.4	19	12
Oil shale, % share	0	1	6
Hydropower & geothermal, % share	4.3	4	6
Nuclear, % share	1.7	11	28

SOURCE: DEPARTMENT OF INTERIOR

6.2 Projected Costs

It is difficult to predict energy costs accurately too far into the future because of the multiplicity of parameters involved in establishing the price data. OPEC nations are presently considering oil price hikes ranging from 10% to 25%. Future price escalations may be even higher. Broad average cost projections made recently through 1990 for various types of energy were presented in Table 5.5.5. It must be emphasized that these cost projections represent one opinion; others may have different opinions. One obvious observation that can be made from these projected costs is that over the next 15 years, the cost of natural gas will increase by a factor of 7.5 compared to 2 to 3 for other energy sources. These cost projections were obtained from "Energy Preview for the Next Five Years," a presentation made by Robert W. Exline to the Manufacturing Committee of the American Boiler Manufacturers Association.

7. PERTINENT FINDINGS AND RECOMMENDATIONS AND OPPORTUNITIES

7.1 Pertinent Findings

Notable points from the statistical information presented in this report can be summarized as follows:

- The Fort Knox reservation is 172 square miles in area with approximately 14,000,000 square feet of occupied facilities; 970,000 square feet of proposed future facilities; and 1,350,000 square feet of facilities proposed for demolition.
- The Fort Knox climate can be characterized as mild with an average winter temperature during January of 33° F. and an average summer temperature during July of 77° F.
- There are a total of 502 heating and boiler plants, large and small, serving 2496 buildings on the post. The primary fuel for the dual fired boilers is natural gas and the secondary fuel is oil. A total of 195 buildings on the installation are provided with comfort airconditioning either by central units or individual units.
- Ft. Knox presently uses four types of fuels; they are, natural gas, electricity, oil, coal and liquefied propane gas. Yearly consumption of each of these in descending order is: natural gas, 2.18×10^{12} Btu; electricity, 4.45×10^{11} Btu; fuel oil, 3.92×10^{11} Btu; coal, 1.7×10^{6} Btu; and liquefied propane gas, 1.0×10^{9} Btu.
- Of the total Kentucky energy consumption, these represent: 1.25% natural gas; 0.00025% electricity; 0.69% fuel oil; 0.004% coal; and 0.055% LP gas.
- Highest peaks in the total monthly energy consumption at Ft. Knox during the past two years (FY75 and FY76) occurred in the month of January.

- Monthly consumption of electrical power was the highest during summer months while monthly consumption of natural gas, oil, and liquefied propane gas was highest during winter months.
- Total energy bill at Ft. Knox for FY 76 was $5.1 million; of the total, electrical power cost represented the highest fraction at $2.18 million, and LP gas was the smallest fraction at only $3,000. With the winter weather returning to a normal temperature pattern, the installation can expect to pay 10 to 15 % more annually in the next several years, even if there is no escalation in the cost of energy. This is based upon a crude analysis presented in another section.
- Unit costs of energy per million Btu at Ft. Knox during FY 76 were: $4.90 for electricity; $0.92 for natural gas; $2.63 for fuel oil; $3.68 for LP gas; and $0.76 for coal.
- The State of Kentucky ranks second in the Union among the bituminous coal producing states.
- Petroleum products account for slightly more than one fourth of the total energy consumed in Kentucky. Furthermore, while crude oil production in Kentucky has been steadily declining, its consumption has been following a rising trend in the recent years.
- Ft. Knox is not close to any existing dam or potential dam site. Nor are there any potential geothermal energy resources located nearby.
- The installation generates approximately 60 tons of refuse each day, representing recoverable heat content of 0.72×10^9 Btu/day.

- Ft. Knox utilizes slightly over one percent of the total volume of natural gas consumed in Kentucky, but natural gas accounts for over 50 percent of Ft. Knox's total energy requirements. Refer to Table 5.1.1 for usage percentages.

7.2 Recommendations and Opportunities

7.2.1 General

The following specific recommendations concern actions which involve energy conservation; cooperative actions with regional civilian populations; research and development; and energy cost effectiveness. It is believed that any action taken by the post to reduce consumption of its primary fuel, natural gas, will have a beneficial impact on the locale. Though the post consumes only a small portion of the region's overall energy supply, its activities can serve as an example to demonstrate the accomplishments which may be expected from a concerted effort and a firm energy policy.

7.2.2 New Energy Sources

A number of government agencies have received considerable Federal funding for research and demonstration projects involving new energy sources and concepts including, solar energy, geothermal energy, wind power, coal liquefaction, coal gasification and a host of others. The post energy officer should maintain close surveillance of the activities of the energy agencies in the area with a view toward cooperation with these agencies to affect energy savings for the post and the region. Such active participation would indicate to the civilian population of the area that Ft. Knox is pursuing an aggressive policy toward easing common energy problems. If possible, such projects should be of a general type for which data could readily be transferred to comparable civilian applications even outside the region. This would further enhance in the public eye the Army's responsiveness to a difficult energy situation.

7.2.3 Power Generation

Consideration should be given to the advantages involved in generation of electrical power on-post. Power for peaking purposes or for

base loading is normally produced through use of steam turbines, gas turbines or diesel generators in conjunction with a central plant concept. Peaking plants can be used to reduce the present electric demand charge of $2.00 per Kilowatt hour of demand. First to be investigated should be the potential for installing a new total utilities plant which involves furnishing all utilities from a single plant. These services would include heating, air conditioning, trash incineration, power production, sewage treatment and possibly water recycling. The combination of services in close proximity permits use of low grade heat from the power generation process which is normally wasted can be used for building heating and cooling. The analysis should include consideration of coal firing and possible phasing out of obsolete older heating plants as well as the location of energy load centers and the extent of distribution systems required.

If a new total utilities plant is not feasible it may be possible to simply add power generation equipment to an existing heating plant. This offers the potential of using the waste heat from diesels or gas turbines for feet water and combustion air preheating which could substantially improve plant efficiency. With this concept, trash incineration and heat storage may also be integrated to further reduce gas or oil consumption.

7.2.4 Heat Pump Applications

A detailed evaluation should be made regarding the possible application of the heat pump concept in the climatic conditions at Ft. Knox. If adequate coefficients of performance can be attained and if supplemental electric heat is not a significant requirement, consideration should be given to such installations for new construction. On a longer term basis, as equipment on existing buildings becomes obsolete, replacement with a heat pump may be justified.

The investigation should include the possibility of a central plant heat pump concept which, though relatively new, appears to be viable and economical if an adequate heat source such as a river or deep wells is available. Again, initiation of a program such as this, would find acceptance not only within the Army but would show to the civilian populace the Army's sincere desire to try unconventional systems in an effort to ease the energy situation.

7.2.5 Emergency Priority Plan

There have been continuing predictions of possible gas shortages in the event of an extremely cold winter. In such a case, the post could participate with industry and government in minimizing consumption during the critical period. A plan should be prepared to curtail or defer those energy consuming activities which are not absolutely essential to the mission of the post. In addition, a list of buildings which can be cut-off for extended periods and areas which can be operated at significantly lower thermostat settings should be established. Savings during this operation could permit heating of a large number of homes in the region during the period of shortage, a secondary contribution by the Army.

7.2.6 Interconnection of Plants

Where distribution systems of major plants are so located that an interconnection can be made inexpensively, such action should be taken. The basic advantage of such interconnection is to permit major maintenance during long periods of low load without interruption of service. In addition, back-up capability is provided in the event of plant or distribution line failure. Though not highly significant, this arrangement may also permit greater operational efficiency by allowing boiler operation at maximum rather than partial loading.

7.2.7 Energy Conservation Construction for Existing Buildings

Larger buildings on the post should be analyzed to determine the cost effectiveness and fuel savings which may be attained through some rather standard construction techniques and operations. These would include installation of insulating glass windows, reduction of fenestration, addition of insulation, reduction of outside air requirements, caulking, use of heat recovery concepts, installation of attic fans and the use of limiting thermostats. In most cases, the cost of these energy saving materials and techniques is quite moderate and pay backs may be realized in a very short time period.

7.2.8 Gas Storage

The installation of a gas storage facility on post appears to offer an opportunity to assist the civilian community during periods of fuel shortage and at the same time insure adequate supply for the post operations. A three-to-four-week supply could be stored during periods of low demand to be available during crisis periods. The storage facility may also be used to reduce peak demand during normal operations thus offering a potential for savings depending on contractual agreements with the gas supplier as the demand charge for natural gas is $1.45 per one thousand cubic feet at present.

A feasibility study should be undertaken to examine the federal and local controls under which the supplier is required to operate, storage capacity of the system, delivery capability, factors which may result in short term shortages and the impact on the concept of price deregulation. If the concept is feasible, storage of natural gas should be pursued further.

Above-ground storage of natural gas in tanks known as gas-holders has been practiced in the past primarily to meet daily peak demands in local

distribution systems (such as the high demand periods in the morning and early evenings). Because of the rather large volume requirements at Ft. Knox (a four week supply may average 200 million cubic feet), storage of liquefied natural gas was suggested by one of the leading tank manufacturers. While this is technically feasible, economics of liquefying, refrigerating and holding operations may be unjustifiable. An alternate method is the underground storage of natural gas in depleted gas reservoirs which is normally practiced. Historically, several such exhausted fields are located within the State of Kentucky. Such a reservoir around Ft. Knox, if available, may prove to be an acceptable alternate for gas storage. However, a detailed study should be made to confirm the applicability of this concept.

The study should also include storage of butane, propane, LPG and any combinations of these. The economic analysis should also consider possible revision of contracts with the supplier to affect fuel cost savings for the post.

7.2.9 Automated Control Systems

A facility-wide analysis should be made to determine the feasibility and economic impact of the installation of automated controls for heating and air conditioning systems. The automated control systems may range from simple time switches to elaborate computerized and centrally-operated programs. Initially, the study should identify those structures which are high energy users but not in continuous operation, thus amenable to programmed shut-off with resultant energy savings. These would include buildings such as gymnasiums, mess halls, service clubs, administration buildings, chapels, industrial and maintenance shops and theaters. Any building with heavy occupancy for only a portion of the day should be examined closely for automated environmental control. In most cases, the installation of an

inexpensive local control with a timer, an outdoor thermostat to vary start-up time with outdoor weather conditions and a minimum setting to prevent freeze up can result in significant savings with minimal initial cost. More sophisticated systems involving air regulation and enthalpy control may be economically feasible in selected buildings. Central computerized monitor and control systems may be highly desirable if maintenance, operation, fire safety and security features are integrated into the system.

7.2.10 Conversion to Coal

Every effort should be made to convert from gas or oil to coal as the prime post fuel. Boilers in each of the existing major plants should be inspected to determine the extent of modification required to permit coal firing. It is understood that some of the boilers were installed with conversion in mind so that stokers can easily be attached and room is available for coal and ash handling equipment. For existing gas or oil fired boilers installed without provisions for conversion, care should be taken to evaluate boiler combustion volume and radiation surfaces as boilers may have to be de-rated for coal firing and additional boiler capacity added to meet current loads.

Should conversions of existing plants be not economically or technically feasible, the concept of installing two or three new major coal-fired plants and abandoning existing gas-and-oil fired installations should be evaluated. This concept will involve the installation of distribution systems and heat exchangers in individual buildings. Though this concept requires a large initial investment, it is possible that increasing gas and oil prices would make it cost effective in a relatively short period of time.

Environmental factors are of extreme importance in the above studies

and analyses. Thus examination of current federal, state and local pollution control requirements will be necessary. Proper cost estimates and life cycle evaluations of pollution abatement equipment needed to meet the standards will be required. In addition, the availability and costs of different types of coal should be determined to establish their impact on environmental control equipment design.

7.2.11 Refuse Incineration

About 60 tons of garbage generated at the Fort is currently being disposed of through land filling. This represents wastage of about 0.72 x 10^9 Btu/day. A study should be undertaken to determine the exact volume, character and heating value of the material and establish the economic feasibility of incineration on-post to extract the available energy. Possibly, the most viable option would be to install an incinerator to operate in conjunction with one of the larger heating plants. Special consideration should be given to the possibility of shutting down a gas-fired heating plant during the summer months if it is possible to provide the lower heating requirements through incineration and heat storage.

If on-post incineration is not feasible or desirable, the City of Louisville or a large industrial manufacturer in the area might be contacted to consider the concept of extraction of energy from refuse incineration for their particular purposes. The post may offer assistance in these studies and evaluations. The overall objective of these actions would be to provide a means of trash disposal from the post at little or no cost and at the same time furnishing low cost energy to the incinerator operator. Care should be taken, however, in making the above analysis to insure that environmental considerations are fully investigated.

7.2.12 Renegotiation of Supply Contracts

Factors such as gas deregulation, power generation capacity shortages, oil price increases, federal and state regulations and environmental considerations will undoubtedly have an effect on the cost and supply arrangements offered by the utilities industries. Ft. Knox personnel should maintain a continuous liaison with the industry to insure that the post takes advantage of any opportunities which become available. Knowledge in this area will undoubtedly have a bearing on decisions concerning many other energy conservation actions proposed for the post. Particular attention should be given to savings which may be taken through electrical peak shaving and on-post fuel storage.

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